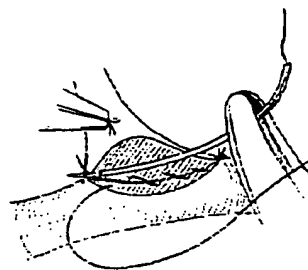
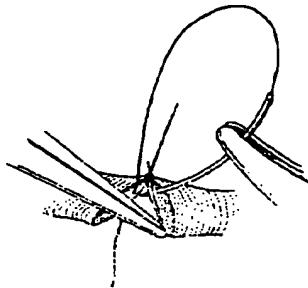
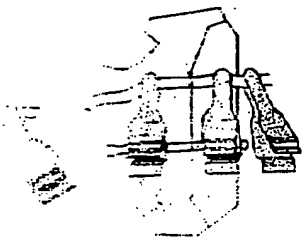
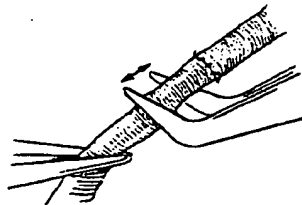
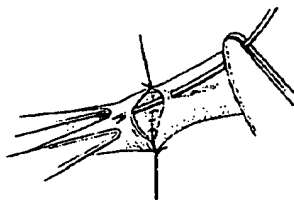
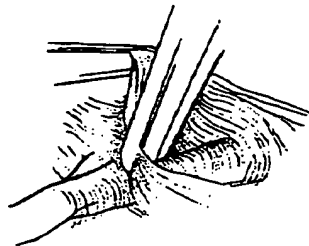
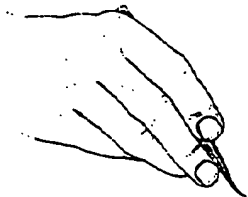


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# PRACTICE MANUAL FOR MICROVASCULAR SURGERY



Second Edition

# **Practice Manual for Microvascular Surgery**

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with 158 illustrations  
illustrated by Nadine Sokol

Second Edition

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## chapter **3** Preliminary suturing exercises

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Plan to spend 3 to 6 hours on the basic suturing exercises described in this chapter. Use the glove rubber practice card described in Chapter 1 (p. 12). Part of the purpose of these exercises is to learn basic suture passing and knot tying. An equally important purpose is to introduce you to good hand position and the avoidance of unwanted movement. In addition, you will gain valuable early familiarity with the operating microscope. If you have not already worked through the important routine of getting comfortable and adjusting the microscope as described in Chapter 2, do so right now.

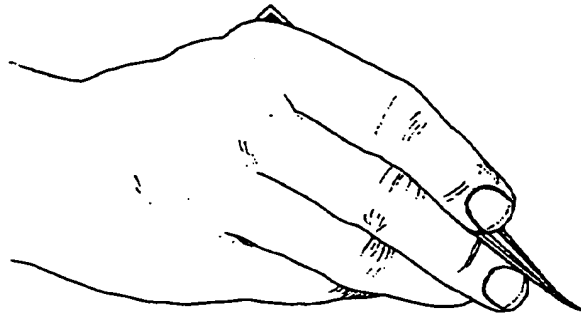
### **THE AVOIDANCE OF TREMOR**

The uncontrolled movements that arise from the intended and unintended actions of your own body are spoken of collectively as *tremor*. Ignore almost all you hear about the prospective microsurgeon's need to avoid specific vices (see introduction). Such tales are irrelevant. Ignore also the notion that a fortunate few are "born with a steady hand." They aren't. Steadiness of hand is achieved by working at it. The prerequisites are a quiet mind, bodily comfort, and a well-supported hand and instrument-holding position.

### **POSITION OF HANDS**

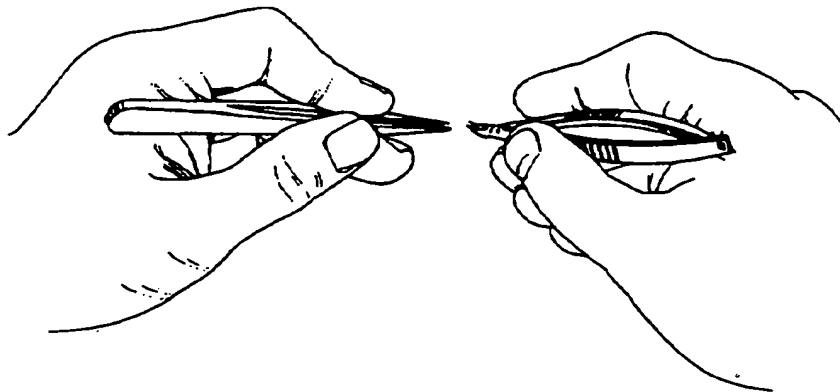
In microsurgery, only the fingertips move. The rest of your hand must rest either directly or indirectly on an immovable surface. If it does not, unwanted movement will make your work impossible.

Start by working in the "writing" position (Fig. 3-1), as this gives more stability than any other. Rest your



**Fig. 3-1**

elbow, your wrist, and the ulnar border of your hand on the table. The forearm should be supinated (knuckles away from you) a little so that the weight of the hand is on the ulnar border. Hold the instrument exactly as you hold a pen when writing (Fig. 3-2), using your thumb and index and middle fingers. The middle finger—the lowest member of the three-digit tripod that holds the instrument—should rest firmly on the working surface, either directly or indirectly via the ring finger.



**Fig. 3-2**

In arranging your three-digit grip on the instrument, bring the thumb and index finger into contact with the underlying middle finger. You will then be able to open and close the instrument with very fine control; any tremor arising from the thumb or index finger will

be markedly diminished by their contact with the steady middle finger.

The writing position described is the easiest to start with. Continue using it until the basic manipulations of suturing become easy. Variations and more freehand positions will come later.

Whatever position you are in, you should never have to hold your whole body rigid to perform fine manipulations. If you find you are doing this or that you are holding your breath while you are working, it means that you are struggling to work with your hands in an unsupported position.

Do not put your hands in a position where they bump into the thing you are working on. This produces a lot of unwanted movement—and microsurgery is basically a battle against unwanted movement!

From this point on through the manual the instructions are given on the assumption that you are right-handed. If you are left-handed, kindly make the necessary translations.

## **CONTROLLING TREMOR WITH DRUGS**

In the introduction, in Chapter 2, and in the section just ended, you have read some important advice on self-care, comfort, and hand position. By following this advice almost anyone can overcome the problem of unwanted movement well enough to do excellent microsurgical work. But not quite everyone. If you have an unusually high state of resting muscle tone and if some aspect of the learning situation is making you anxious, you may still have a problem. You may become locked into a vicious cycle in which anxiety and tremor potentiate each other. In such a state you may be unable to achieve the early successes that would give you confidence and steadiness. If this is the case, I advise you as a short-term measure only to take a small dose of the highly effective beta-blocker propranolol (Inderal) an hour before you practice. Be sure you get your physician's approval before doing this. After some successful sessions

have boosted your confidence, see how well you work without the medicine. If the problem is still just as bad, even when you have overcome your anxiety, it could be that microsurgery is not for you.

***Do not, under any circumstances, use a tranquilizing agent to overcome a tremor problem.***

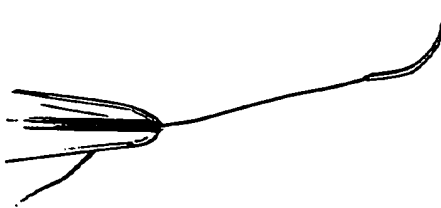
### **HANDLING THE NEEDLE WITH THE NEEDLE- HOLDER**

Put the straight jeweler's forceps (No.3) in your left hand and the needle-holder in your right hand. Use a 100-micron, flat-bodied microvascular needle with not more than 12 cm of thread (10/0 nylon) attached. When you are not suturing, park the needle on the sticky side of a piece of adhesive tape, doubled over. When picking up the needle from the sticky patch, get hold of the needle—do not pull on the thread.

### **GETTING HOLD OF THE NEEDLE WITH THE FORCEPS**

At first grasping the needle is difficult because it is highly unstable in the needle holder and jumps around so that it points in any direction other than the one you want. The best way to pick up the needle is to proceed as follows.

Get hold of the thread with the left-hand forceps at a point 2 to 3 cm away from the needle (Figure 3-3, A).



**Fig. 3-3, A**

Dangle the needle until it just comes to rest on the surface below (Fig. 3-3, B). It can now be made to swing around to point in any direction, and the angulated (right-hand) forceps can easily get it (Fig. 3-3, C). This can be done with the naked eye on a

suturing always  
involves a  
needle

Thread = suture

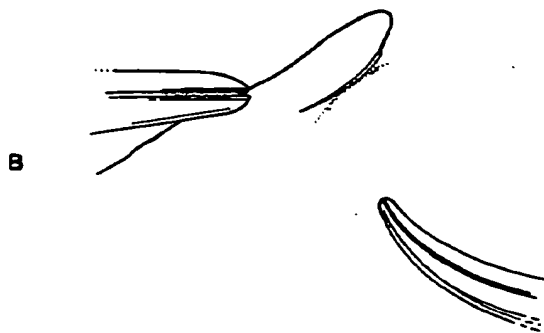


Fig. 3-3, B

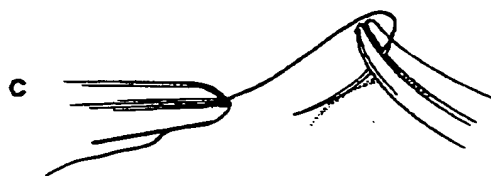
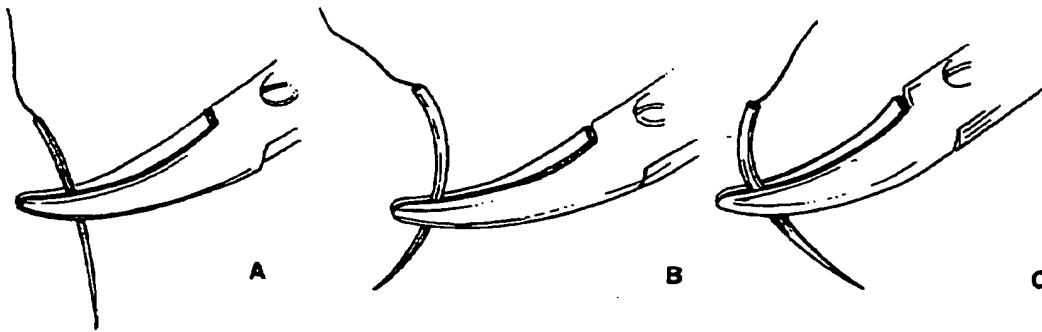


Fig. 3-3, C

white surface, or under the microscope. If the needle is still not pointing in quite the right direction, you can make minor corrections either by touching the needle with your left-hand forceps or else by partially relaxing your grip and nudging the needle tip against another firm object. You will soon learn that your needle is in a *stable* position if it is set up at  $90^\circ$  to the axis of the tips of the forceps (Fig. 3-4, A). The needle is *unstable* if its long axis deviates much from this position (Fig. 3-4, B and C). If you are using a flat-bodied microvascular needle, the problem of needle stability is not as severe.

In addition to getting the needle to point in the right direction it is also important that you hold the needle at the right point along its length. If you hold it too near the tip (Fig. 3-5, A), it will point downward. If you hold it too near the thread end (Fig. 3-5, C), it will point upward. *The needle tip should point horizontally, not upward nor downward.* Therefore you should hold the needle just behind its midpoint (Fig. 3-5, B). An upward-pointing tip only produces

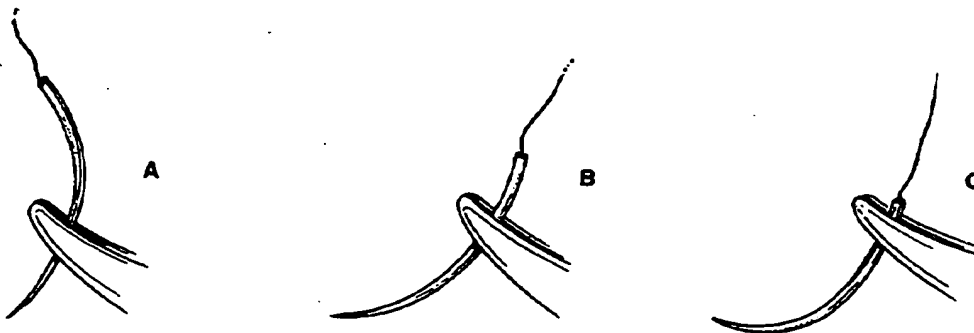


**Fig. 3-4**

inconvenience, but a downward-pointing tip produces a very real danger and you should strongly avoid it. When you do an anastomosis, there is serious risk that the downward-pointing needle tip will go through not only the wall of the vessel that you want to suture but also through the opposite wall. The result is a "through-stitch," which is one of the fundamental faults of anastomotic technique.

Sometimes to get the needle set up in the right-hand forceps correctly, you will have to pass it from one instrument to the other. Whenever you do this, let go with one instrument as soon as you have it with the other. If you hold onto the needle with both instruments at once, you will easily break it.

*Whenever you start to pass the needle, get it set up*



**Fig. 3-5**

*in the needle-holder pointing right in the line it is intended to travel. Otherwise, you will find yourself trying to make a delicate and crucial adjustment just when things are getting difficult.*

## POSITION OF THE NEEDLE-HOLDER

The position in which you hold the needle-holder depends on the direction in which you are going to make your needle travel. In the natural "forehand" position, the needle-holding forceps is held with the tips pointing away from you and toward the left. This is suitable for passing the needle from top right to bottom left. You must not restrict yourself to this one position, or your style will be confined to working under artificially easy conditions. As your initial practice sessions progress, you must rotate the direction of your suture line around the clock in order to learn the various positions (See Fig. 3-17).

Changing direction is done partly by rotating the needle-holder around its long axis and partly also by altering the position of the hand. When the hand position is shifted, the main change is in flexion or extension of the wrist. The position of the fingers stays relatively unchanged.

Practice handling the needle in each rotation position of the needle-holder, and you will soon see that the needle can be made to point in just about any direction you want. Also, practice flipping the needle-holder quickly around from forehand to backhand. You will often have to do this when tying knots in order to pick up the thread easily.

## PASSING THE NEEDLE THROUGH TISSUE

The needle should pass through the tissue perpendicular to the surface of the tissue. To achieve this, the tissue edge must be everted a little to provide the distortion that is necessary (Fig. 3-6). Eversion is produced by placing the tips of the left-hand forceps on the underside of the tissue and gently pushing the tissue edge up into eversion while spearing the tissue with the needle simultaneously.

*Do not grab the thickness of the tissue between the*

*Knots are tied,  
not sutured →*

*needle  
penetrates the  
tissue*

*always with suturing.*

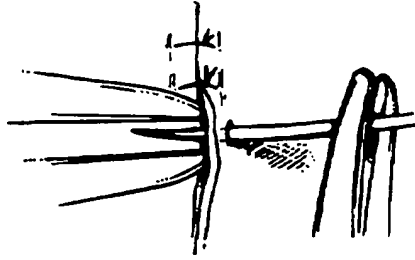


Fig. 3-6

jaws of your left-hand forceps in order to bring it into the position you want. This is a serious breach of atraumatic technique and should be avoided at all times, even on glove rubber. If you cannot bring the tissue edge up into eversion by the method recommended, two alternate methods are available. One is to pick up the next adjoining suture and lift it gently, which will often produce something approaching the desired effect. The other is to pick up not the thickness of the tissue but the surface of the tissue at a point a little distant from the actual tissue edge. This can be done with rubber, but it is a good deal easier to do with vessel wall tissue because there is always a little fibrous adventitia that you can pick up to produce the desired elevation of the vessel edge.

The needle must also come out the other side as nearly perpendicular as possible. Put the tip of your left-hand forceps on the top side of the tissue just beyond the place where the needle is going to come through (Fig. 3-7). Then when the needle

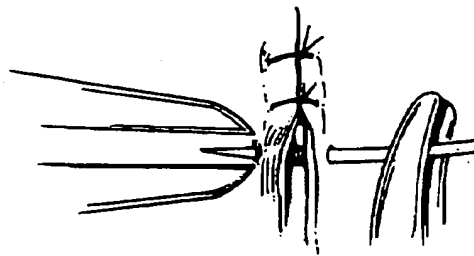


Fig. 3-7

suturing always involves piercing of tissue with a needle or sharp instrument that is always attached to a thread or suture.

comes through, it will bend the tissue upward as it comes out and pass through it perpendicularly.

The width of the "bite"—the distance between tissue edge and the needle hole—should be about three times the thickness of the needle itself. The bite on one side should be equal in width to the bite on the other side, and your needle should cross the suture line not diagonally but exactly at right angles (Fig. 3-8).



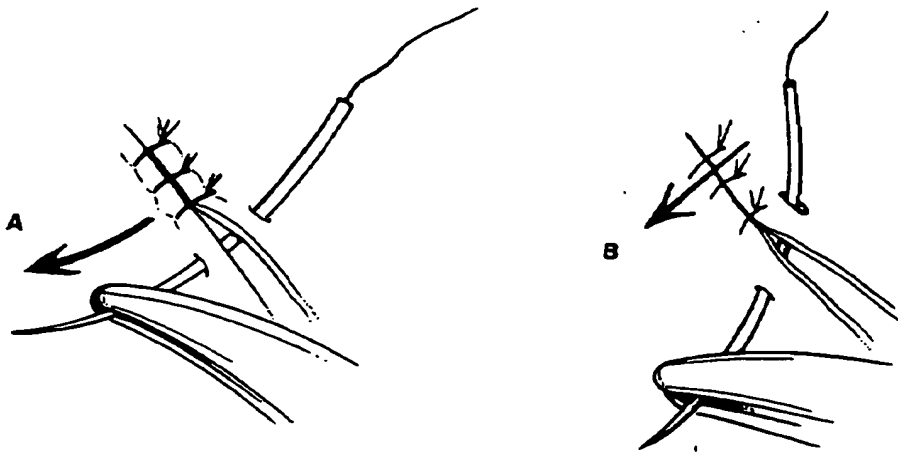
Fig. 3-8

Do not feel at the outset that you have to put the needle in one side and bring it out the other side all in one movement. This will come after a little practice. Rather, pass the needle through the first side and bring it out completely; then pass it through the second side as a separate maneuver.

\* When bringing the length of the curved needle through the tissues, let it follow its own curvature (Fig. 3-9, A). Pull it through with two or three short, straight pulls. Do not attempt to pull it through in one straight movement because this can cause gross distortion of tissue and unnecessary enlargement of the needle hole (Fig. 3-9, B).

### CHANGING MAGNIFICATION

When you have passed the needle through both sides using high magnification, hold the needle in your left-hand forceps and pull the thread through.



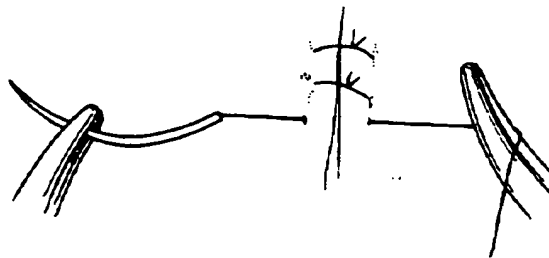
**Fig. 3-9**

Change to low magnification at this point so that you can see the end of the thread coming.

**PULLING THE THREAD THROUGH**

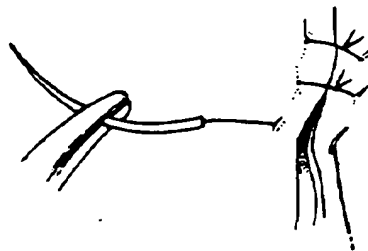
Keep the thread parallel to the direction of the entry-exit line as it comes through, using the tip of the right-hand forceps as a guiding pulley (Fig. 3-10, A). This avoids damage to the tissue caused by

Thread or suture is pulled through the tissue by the needle.



**Fig. 3-10, A**

angulation of the thread at the entry hole (Fig. 3-10, B). When the end of the thread comes into view,



**Fig. 3-10, B**

stop pulling and let the needle drop. It is not necessary to see where it falls. The short end of the thread should be about 3 mm long. Get any redundant coils of thread completely out of your field of vision before you start tying the knot.

### TYING KNOTS

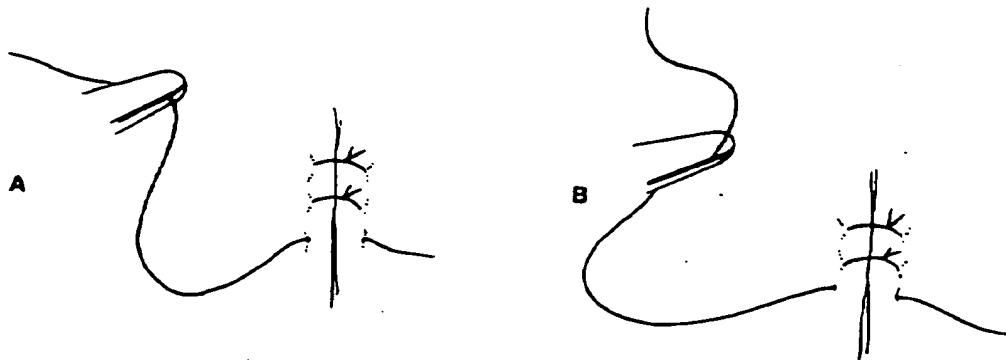
Learning to tie knots in fine nylon is one of the principal sources of frustration in learning microsurgery. When you see it being done by an expert, the movements are fluent, rapid, and effective. Yet when you first try it yourself you will encounter every kind of entanglement and exasperation.

Tying a knot consists of four separate actions, and each of these presents its own particular difficulties. First, the thread is picked up with the left-hand forceps; second, a loop is made on the tip of the right-hand forceps; third, the short end of the thread is picked up with the right-hand forceps; and fourth, the loop is pulled off the right-hand forceps and the knot is tightened.

### PICKING UP THE THREAD WITH THE LEFT-HAND FORCEPS

If you passed the needle through the tissues from right to left, you now have on the right of the suture site a short end of thread and to the left of the suture site a much longer length of thread that disappears out of sight. Take hold of the longer length of thread with the tip of the left-hand forceps about 1 cm from the suture site. The length of thread that now lies between your left-hand forceps and the suture site will be referred to as the "loop length." The loop length should be three times as long as the short end.

When you pick up the thread with your left-hand forceps, pick it up so that the part that you are going to tie with, the loop length, comes out from the side of the forceps which is toward you (Fig. 3-11, A). This makes knot-tying ten times easier. If you have the loop length coming out from the side of the forceps that is away from you (Fig. 3-11, B), then it is difficult to make it into a loop on the right-hand

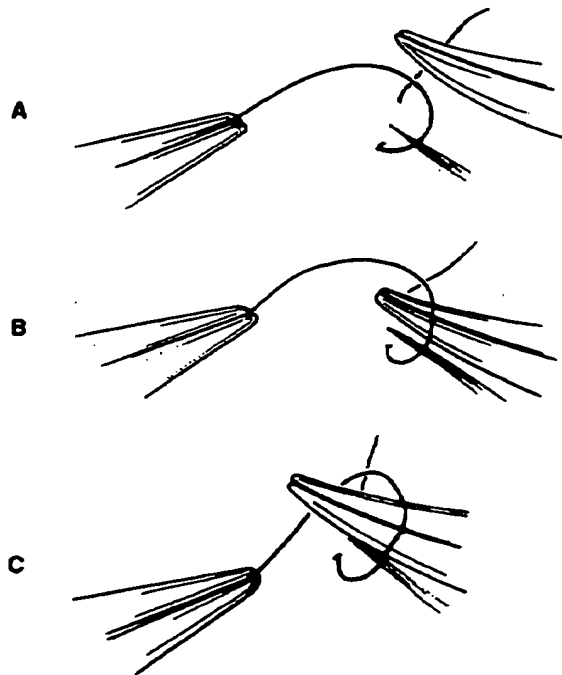


**Fig. 3-11**

forceps and, even when you succeed in doing this, the loop will constantly have an urge to fall off the forceps. If you start by picking up the thread with the left-hand forceps in the correct manner, these difficulties do not arise.

#### **MAKING A LOOP**

Having picked up the thread correctly in the left hand, it is usually simple to turn it in a single loop around the tip of the needle holder (Fig. 3-12). Sometimes this is done by winding the forceps



**Fig. 3-12**

tying a knot by making a loop (different than suturing)

around the thread, and sometimes it is achieved more easily if the thread is wound around the needle-holder. Most often a combination of these movements is used.

Put the loop well onto the tip of the needle-holder and keep it loose. If it is too near the very end of the needle holder or if it is too tight, it will easily fall off. Do the loop making quite near to where the short end is lying; then you will not have to carry your loop any distance before you pick up the short end.

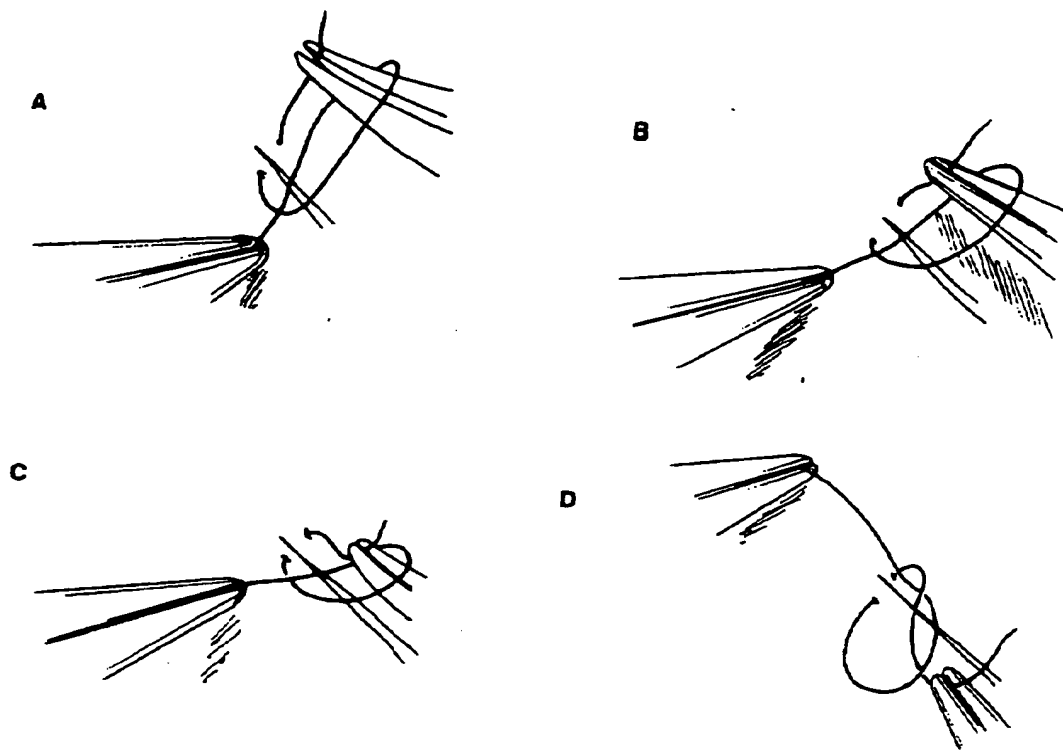
A final pitfall in loop making is that when the loop has been made and the needle-holder holding the loop has been opened, ready to pick up the short end, the loop can fall off not both but just one of the jaws of the needle-holder, ending up between the two jaws. If you do not notice what has happened, and you go ahead and pick up the short end, you will find yourself in strenuous difficulties when you try to slip the loop off the right-hand forceps, because it will be caught between the jaws.

#### **PICKING UP THE SHORT END**

If the short end sticks up in the air cooperatively, there is never any difficulty in getting hold of it with the needle-holder (Fig. 3-13, A to C). More often than not, however, certain difficulties will present themselves: (1) the end may be too short, (2) it may be at an awkward angle, (3) it may be hidden, or (4) it may be lying on a flat surface. When you encounter one of the above, *do not* make repeated similar attempts to pick it up. Look at the situation. Analyze the difficulty and take action to alleviate it. Then go ahead and pick the end up—easily.

There are specific ways to correct or avoid the above difficulties.

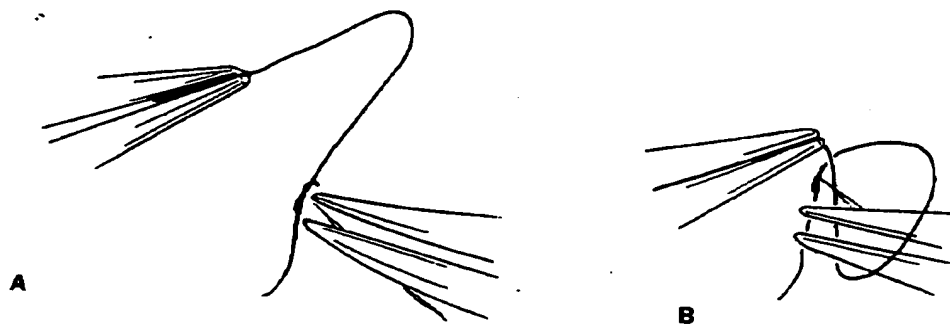
If the short end is too short, pull it out longer. The usual reason for the end being too short is that you started out making the loop length too short and then



**Fig. 3-13**

pulled some of the short end through when making the loop.

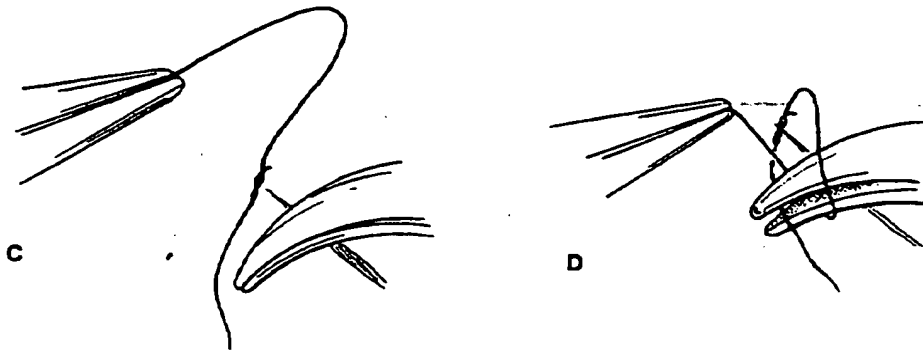
If the thread is at an awkward angle for your needle-holder to pick it up, (Fig. 3-14, A and B) turn



**Fig. 3-14, A and B**

Knot tying  
is different  
than suturing.

the needle-holder around until it is at an angle where it will pick up the thread easily. It is a good deal simpler to make this change in the position of the needle-holder *before* rather than after you have made the loop. Therefore it pays to take a look at the short end and see how it is lying, before you start making your loop. Determine the best way to point your needle-holder so that you will be able to pick up the short end easily when the time comes. Put your needle-holder into this position, *then* make the loop and then immediately you can pick up the short end without difficulty (Fig. 3-14, C and D). If you do it in



**Fig. 3-14, C and D**

this way, you will not have to accomplish an awkward change in the position of the needle-holder once you have made the loop.

If the short end is hidden or if it is obstinately stuck by surface tension to a flat surface, get hold of the short end with both pairs of forceps and bend it vigorously into a tight right-angle kink. This kink will stay and will provide you with a place where the thread can easily be picked up.

Often, when severe difficulties arise, it is wiser to drop your loop altogether and use both instruments to get the short end into a better position and then start the knot over again under friendlier circumstances.

Once you have picked up the short end, pull it gently through the loop with the needleholder (Fig. 3-13, C and D).

### COMPLETING THE FIRST HALF KNOT

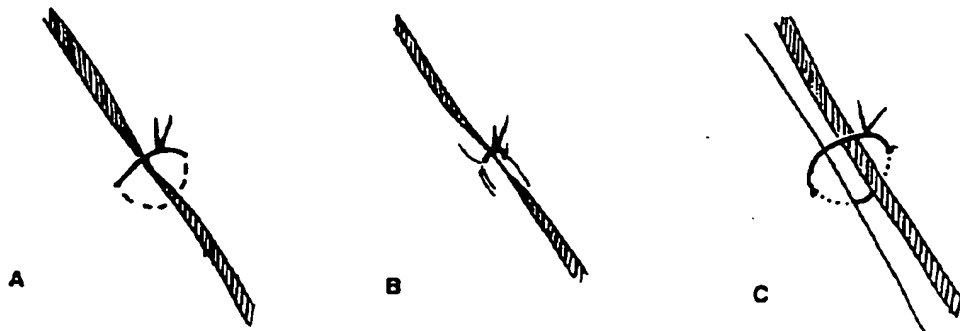
As you do so, allow the loop to fall off the tip of the needle-holder, and your first half-knot is made. Draw it to a gentle but not final degree of tightness.

Do not let go of the thread with the left hand. Hold on to it so you can go ahead and make the loop for the second half knot.

### THE SECOND HALF KNOT

In making the second half knot, the sequence of movements—making the loop, picking up the short end, and pulling the short end through the loop—is repeated. Much of the exasperation of knot tying arises from trying to pick up the short end from a position of disadvantage (Fig. 3-14, A and B). This is an even greater problem with the second half knot than with the first. Do two important things before you make the loop: first, turn the needle-holder and point it in a direction that will make it easy to pick up the short end (Fig. 3-14, C). Second, put the jaws of the needle-holder *near* the short end so that once you have the loop made, you will not have to make a long journey with the needle-holder to pick up the short end. Don't make the loop until the needle-holder is correctly poised. When you make the loop, bring the loop to the needle-holder, not vice versa. Then you can go straight to picking up the short end without a struggle, without turning the needle-holder around, and without making a journey (Fig. 3-14, D). The first hundred times you pick up the short end you will have to think hard about this. After that it will start to become automatic and you will forget what it was that you ever found difficult.

Having picked up the short end, pull it through the loop and the second half knot is made. Tighten the completed double knot, bringing it—by eye, not by feel—to the degree of tightness that just brings the tissue edges into contact.



**Fig. 3-15**

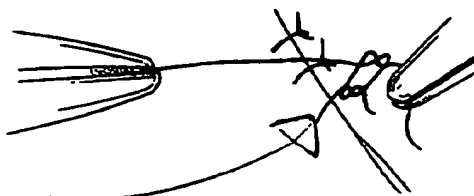
The little circle of suture material enclosed within the tissue should remain visible (Fig. 3-15, A). If it disappears you have overtightened the knot and traumatized the tissue.

#### **SLIDING THE KNOT TIGHT**

If the tissue edges are a little unwilling to come together, tightening the second half of the knot requires particular care. Two things must be done: first, the tissue edges must be brought together, then the knot must be locked. If the knot locks prematurely, before the tissue edges are together (Fig. 3-15, C), the suture is useless.

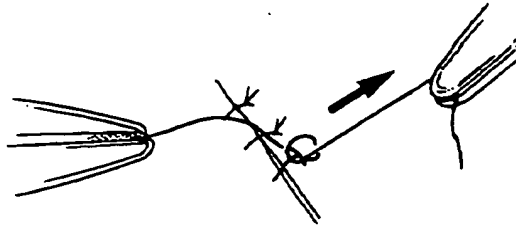
There is a useful way of finally tightening the knot, which ensures that the tissue edges are brought together to just the right extent before the knot is finally locked. Start with both halves of the knot completely loose (Fig. 3-16, A). Pull steadily out to

\* This is called an air knot.



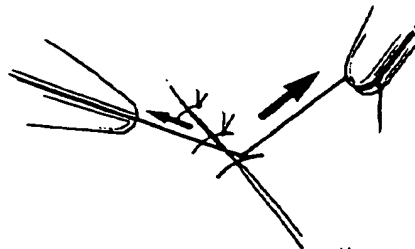
**Fig. 3-16, A**

one side on the short end only, keeping the long end slack (Fig. 3-16, B). The first half of the knot will



**Fig. 3-16, B**

progressively tighten, while the second half stays loose. Now, keeping up the pull on the short end, draw the other thread right across to the opposite side of the suture line and pull on it (Fig. 3-16, C); the second half of the knot will come tight.



**Fig. 3-16, C**

#### **HOW MANY HALF-KNOTS?**

Always use one extra half-knot for security, even when your first two have resulted in the best possible square knot.

If you used the sliding maneuver, your first two half-knots will give you "one straight thread and two half-hitches." For security this should be followed by two more half-knots.

#### **RETRIEVING THE NEEDLE**

You can be sure of retrieving the needle, wherever you left it, if you cut the suture ends in the right order. Cut the short end first and discard it. Then

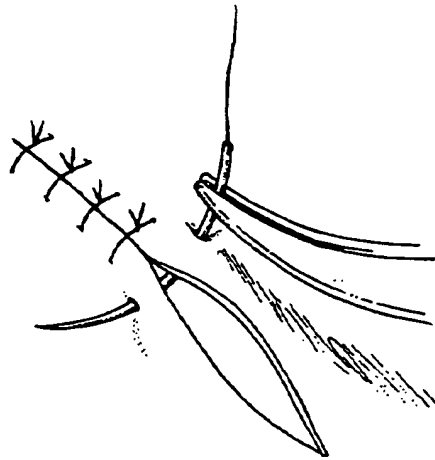
hold onto the long thread and cut it close to the knot. Without letting go of the long thread, pull on it, and the needle will come into view.

The suture ends should be cut short and neat. If the ends are too long, they will get mixed up with the next suture. If you have made a neat square knot, your two thread ends will lie at right angles to the incision line and will not tend to stick down through the gaps into the lumen.

You should try to place two sutures per millimeter in initial practice exercises.

**PROGRESSION OF  
EXERCISES FROM EASY  
TO DIFFICULT**

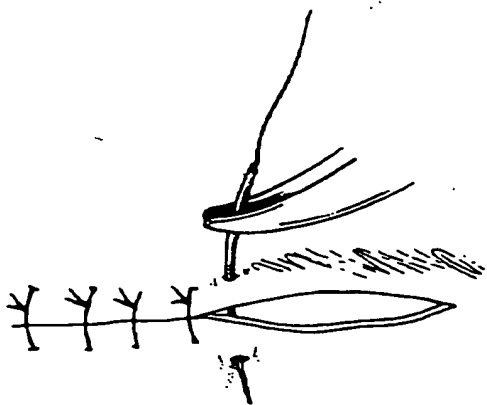
To make things easy for yourself at the outset, you should first arrange the work so that the incision runs from top left to bottom right (Fig. 3-17, A). This



**Fig. 3-17, A**

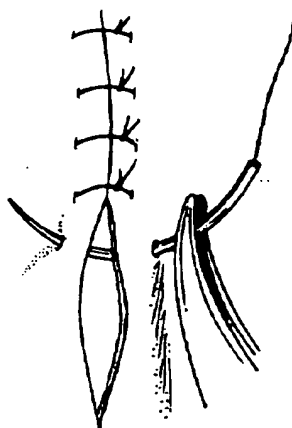
enables you to hold your needle holder in the most comfortable and natural position. When you can suture easily in this position, turn the practice sheet around so that the incision crosses your field of vision horizontally (Fig. 3-17, B). In this position you have to both rotate your instrument counterclockwise in your hand and also flex your wrist a little to pass

suturing  
involves  
penetrating the  
tissue with  
the needle  
that is  
attached to  
suture or  
thread.



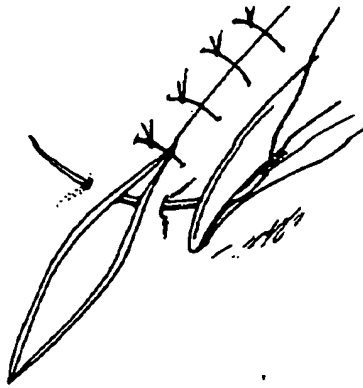
**Fig. 3-17, B**

the needle in the right direction. The next exercise, which is slightly more difficult, is to arrange the practice sheet so that your incision crosses your field of vision vertically (Fig. 3-17, C). Here you have to rotate the instrument clockwise and extend the wrist somewhat to get the right direction of movement.



**Fig. 3-17, C**

Finally, when you find all these positions easy, go on to the most difficult of all, which is with the incision passing from top right to bottom left (Fig. 3-17, D). In this "backhand" position, it is best to hold the needle

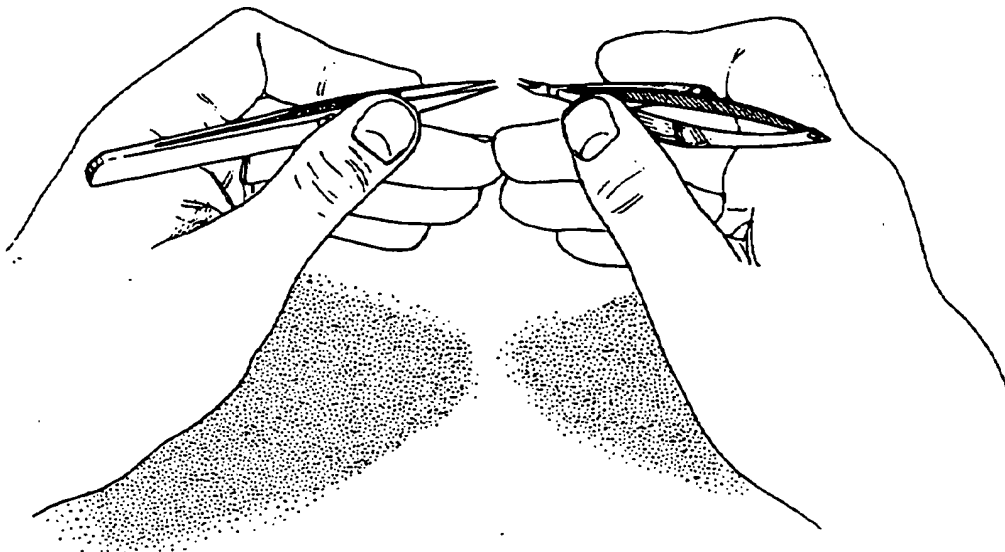


**Fig. 3-17, D**

holder with its points toward you, have the needle pointing backward, and suture away from yourself.

### **TOUCHING YOUR HANDS TOGETHER**

When you are ready to attempt a more freehand working position, you must learn to work with your hands touching together. This is a useful way of diminishing unwanted movement when no hand support is available beyond the wrist. Touch the extended middle or ring fingers of each hand together with moderate pressure (Fig. 3-18). Then



**Fig. 3-18**

rest your instrument-holding digits on the fingers that are touching.

To learn finger-touching you must be persistent. You may find that it feels unnatural and cramped at first. Most people do. Do not give up. After a few hours of mild discomfort, your hands will relax in their new relationship and you will have acquired an important extension of your skill.

### TYING A SURGEON'S KNOT

In microsurgery, suturing under tension is often condemned, and rightly so. Still, there will be many times when you have to overcome the natural elastic retraction of tissues as you suture. For this, a surgeon's knot with a double throw on the first half knot is very useful. To cast a double loop give yourself an extra long loop length to work with. Place the double loop on the needleholder a long way from the tip to guard against its natural tendency to spring off the instrument. Once you can easily make a double loop you will find the surgeon's knot rather more secure and predictable in its action than the sliding maneuver shown in Fig. 3-16 (the only advantage of which is that the sliding maneuver lets you avoid double-looping when you are starting out).

knot tying involves loops & suture material or thread (doesn't involve needle or penetration of tissue)

### SUTURING WITH YOUR LEFT HAND

There are rare but critical moments in microsurgery when your right hand has no way of passing the needle in the direction you want it to go. In preparation for such moments, do a little suturing with the roles of your hands reversed and learn to respect the competence of your left hand. It is not a stupid hand, in fact, with a little encouragement and praise you can get it to do almost anything.

# ELECTIVE INCISIONS AND SCAR REVISION

Albert F. Borges, M.D.

Foreword by John Marquis Converse, M.D.



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# *Plastic Surgical Technique*

# 4

THE subject of surgical technique is extensive and obviously cannot be covered in one chapter. Instead, this discussion will focus on my own approach to the treatment of wounds and the instruments and sutures I find most useful. No doubt the preferences of other surgeons will differ from mine. I can only point out that the techniques touched upon here have worked well for me [32].

So-called plastic surgery of a skin wound is nothing more than the suturing of a wound with diligent and meticulous care. The plastic surgeon aims at perfection and does not care so much about the time involved to obtain it. Nevertheless, for a surgeon of training and experience, the difference between the time taken to suture a wound carefully and to suture it carelessly is almost negligible.

It is critically important to know one's limitations, to know how much can and cannot be accomplished in obtaining a satisfactory scar. Then the patient can be told what to expect. The limitations imposed by factors not within our control have already been discussed in the chapter on scar prognosis. Here, without reference to these factors, the role that proper surgical technique plays in a good operative result will be evaluated, keeping in mind the reservation that even the finest technique cannot entirely undo the damage of injury.

The patient should be placed on the operating table in a comfortable position. The knees should be elevated, especially in prolonged surgical procedures (facelift, for example), in order to prevent postoperative backaches.

Illumination of the operative area should be adequate and perpendicular to the region where the operation is to take place. Oblique or tangential lighting will cast shadows by the surgeon's and assistants' heads and hands.

When operating on the head or extremities of a patient, the surgeon should sit down. "Never stand when you can sit down," Gillies advised [84]. A seated position makes one's work less tiring. If the surgeon's feet are on a stool, he will thus brace himself further, his whole body will be better balanced, and he will gain more control of his delicate movements. A comfortable working position improves accuracy and reduces fatigue.

### *Instruments*

The basic plastic surgical set of instruments most often used in the surgical closure of wounds, scar revision, or excision of skin lesions is the following (Fig. 4-1):

1. Towel clips or forceps, small size (9 cm, Backhaus). At times, especially in operations on the face, it is more convenient to suture the drapes, with 4-0 silk, to the skin surrounding the operative area so that they will not tend to slide downward.
2. Gauze sponges, 10 by 10 cm, used for sponging and as bandage.
3. Round toothpicks and dye (methylene blue) in a medicine cup, used to mark the skin when planning elective incisions.
4. A syringe with Luer-Lok control and metal thumb and finger rings for injecting the local anesthetic, as well as for flushing traumatic wounds with saline. It can be either the 5- or 10-cc size. It is used with 25-gauge hypodermic needles, 1.5 cm and 5 cm in length. "Throwaway" needles as a rule have sharper points. A 20-gauge needle is used to withdraw the anesthesia.
5. Retractors, Senn double-ended (16 cm), with three-pointed end (not dull) and one solid blade.
6. Scalpels, No. 3 handles, with No. 15 and No. 11 blades.
7. Hooks, small and sharp, Frazier (14 cm), with pointed end.
8. Thumb tissue forceps with 1 and 2 mouse teeth and light, delicate tip with easy spring (Adson's, 12 cm).
9. Scissors, small curved-on-flat Stevens (11 cm), which is used in excising and undermining tissue, and the straight Stevens scissors, which is used for cutting ligatures and sutures.
10. Needle-holder, Webster (13 cm), with smooth jaws with which the suture material can be held easily without slipping when tying knots.
11. Catgut, 4-0 chromic with needle, used for ligatures and deep tissue approximation. Silk, black, braided, atraumatic, 6-0, with 3/8 curved cutting needle.
12. Hemostats, curved mosquitoes (14 cm).
13. Medicine cup with normal saline solution to cleanse the wound.

### *Elective Incisions and Scar Revision*

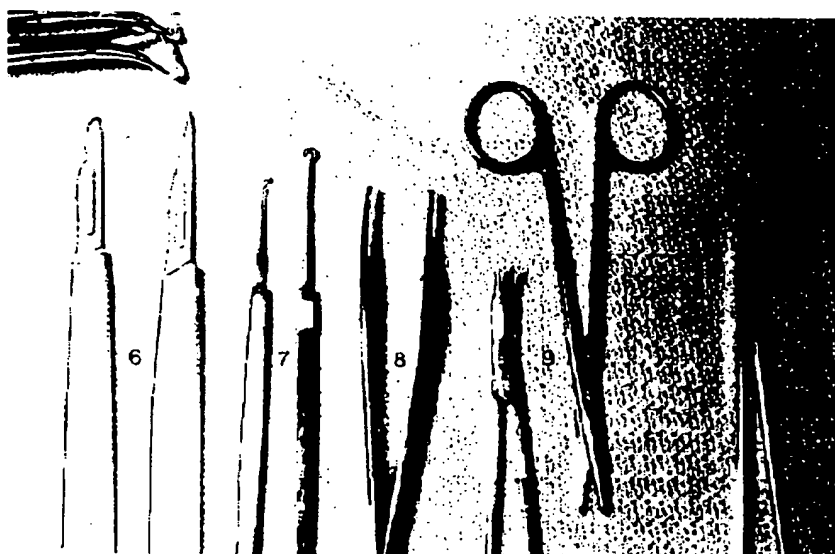
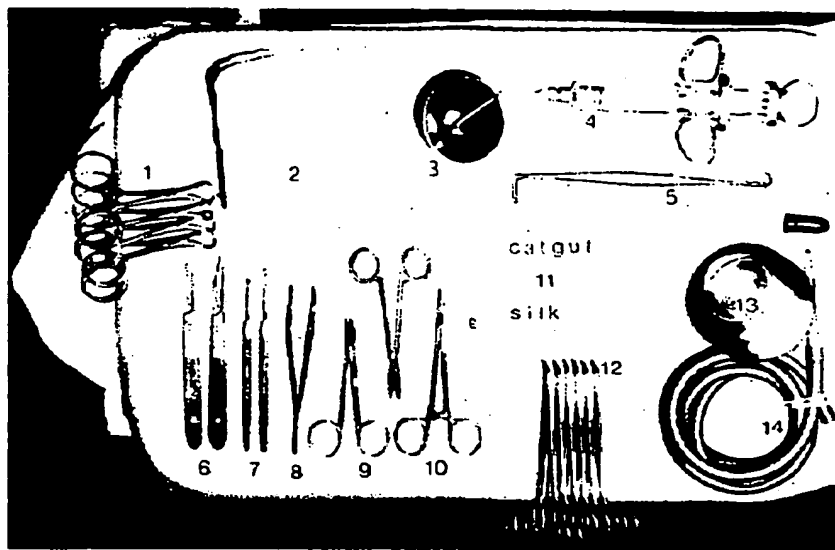


FIG. 4-1. Basic plastic surgical set of instruments.

- |  |  |
|--|--|
| 1. Towel clips   | 9. Stevens scissors  |
| 2. Gauze sponges                                       | 10. Webster needle-holder  |
| 3. Round toothpicks and methylene blue in medicine cup | 11. 4-0 chromic catgut and 6-0 silk with atraumatic cutting needle |
| 4. Syringe and hypodermic needles                      | 12. Mosquito hemostats   |
| 5. Senn retractor                                      | 13. Medicine cup for normal saline solution                        |
| 6. Scalpels  | 14. Suction tubing with standard medicine dropper                  |
| 7. Skin hooks  |  |
| 8. Adson forceps with teeth                            |  |

14. Suction tubing with standard medicine dropper used as suction tip. This is easier to use rather than the regular metal suction tubes (Frazier or Adson). Its rubber bulb may be placed over the tip to shut off suction when not in use. Using suction in a wound to cleanse it of blood and foreign particles is superior to the frequent use of gauze sponges because it is less traumatizing, removes small particles better, and does not interfere with the surgeon's vision.

### *Making the Incision*

It is advantageous to crosshatch the incision area beforehand with a needle dipped in methylene blue, or with the point of the scalpel (scratch marks). This is helpful in re-aligning the wound edges to facilitate subsequent suturing.

The No. 15 blade is the one used most frequently by plastic surgeons. This blade is mounted on a No. 3 surgical handle. For small or sharply angled incisions (e.g., W-plasty), the pointed No. 11 blade is preferred.

Elective incisions should be performed perpendicular to the skin surface [48]. The incision should be made at a slant only when making free hair-bearing skin grafts, following the angle of the hair follicles. The skin should be kept taut and firm while making an incision. For delicate, accurate incisions the scalpel may be held like a pencil (Fig. 4-2). Elective incisions always should be as close to the RSTL as possible to obtain minimal scarring. When excising deep structures, care should be taken to make the incision of sufficient size so that the skin does not have to be retracted excessively for adequate exposure.

### Suture Material

The first question a young surgeon is likely to ask an experienced surgeon is "What suture material do you use?" He asks the question out of a desire to improve on his results, thinking that this factor is an important one in obtaining a fine scar, somewhat analogous to using good ingredients in baking a cake. Nothing could be further from the truth: A fine scar depends less on the type of suture material used than on the region of the wound, its relation to the RSTL, and other factors mentioned in the chapter on scar prognosis, as well as on the technique in inserting and tying the suture material. I prefer 6-0 black, braided, atraumatic silk sutures in most operations on the face. Larger sizes (5-0 and 4-0) are used wherever greater tensile strength is required. The facility with which the silk suture is tied and the greater ease of wound edge tension adjustment appear to make this material preferable.

The atraumatic suture (swaged needle) has advantages. It needs no threading, it does not become unthreaded, the injury to the tissues is minimal, and it comes already sterile. The "plastic" type has smaller needles, which are narrow and very sharp. The cuticular

tying is different  
inserting  
of needle  
& thread or  
suture = suturing



FIG. 4-2. Writing-pen grasp of scalpel. Thickest part of handle is grasped between thumb and first two fingers. This position of knife is employed for delicate incisions.

*needle*  
type is larger and not so sharp; it is preferable when the skin is thick, since it permits the surgeon to pierce both skin edges with only one stroke.

For continuous temporary subcuticular stitches I prefer to use 4-0 monofilament nylon. It holds the wound better than silk and can be left in the wound much longer without signs of inflammation. When the stitches are going to be left in a long time (10 days to 2 weeks) before removal, I prefer to use 5-0 continuous whipstitch monofilament nylon rather than interrupted silk.

#### TECHNIQUES OF WOUND SUTURE

Before placing any skin suture, it is desirable to undermine the wound's skin borders slightly in order to facilitate proper insertion of the needle and accomplish the desired minimal eversion of the skin borders.

*into tissue*

##### *Simple Interrupted Suture*

The simple interrupted suture is the suture most frequently used. It may be passed through the skin with straight needles. However, more accuracy is achieved by using small curved needles mounted on holders. The needle-holder can be large or small, but should have thin, pointed claws in order to hold the small needle properly without breaking it.

*suturing involves passage of needle through tissue.*

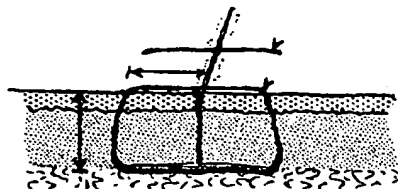


FIG. 4-3. Simple interrupted suture. Suture enters skin at a distance from wound's edge equal to thickness of skin (arrows).

Observe in Figure 4-3 the following technical details in a schematic representation of a simple interrupted suture:

1. The thread has entered the skin at a distance from the skin border (horizontal arrow) equal to the thickness of the skin being sutured (vertical arrow).
2. It then traverses the skin, not precisely in a perpendicular fashion, but in a slightly oblique manner, in such a way as to form an isosceles trapezoid. This brings about a slight eversion of the skin borders, or at least prevents inversion.
3. The knot is tied away from the wound edges, not over the wound itself. Three knots are tied to prevent unraveling. The ends are cut short to avoid interference with the tying of neighboring stitches.

penetrates  
the skin

knot tying different  
than suturing

In order to distribute the wound tension more evenly among the sutures, it is preferable to place the sutures in the order shown in Figure 4-4. Alternatively, the white sutures should be done first and then the others.

Another satisfactory method is to insert the first suture in the middle of the wound, the next midway between this point and the extremity of the wound, and so on. The first sutures (white) should not be tied too tightly, even though this often results in their not completely approximating the wound edges until the other sutures (black) are placed.

How many sutures are needed, and how far apart should they be? The answer is: as many sutures as necessary, placed as close together as necessary, for satisfactory coaptation of wound edges. Wounds that follow the RSTL need fewer stitches than those that cut across them. Their edges can be brought together with fewer stitches. It is better to increase the number of sutures than to increase the size of the thread. By increasing the number of stitches one distributes the tension more evenly, thus preventing the thread from cutting the skin and producing stitch marks.

The main advantage of the interrupted stitch over the continuous stitch is that one may adjust more precisely the tension of each suture at each segment of the wound according to the spreading force that exists.

\*  
penetration  
of tissue  
with  
suturing

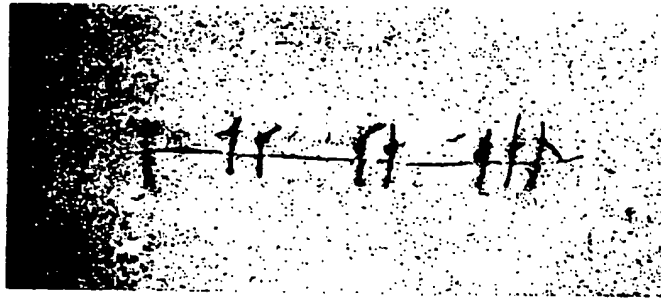


FIG. 4-4. Order in which skin sutures are placed so tension of wound may be more evenly distributed. Suture color is only for diagrammatic representation. (From Borges, A. F., *Rev. Confed. Méd. Panam.* 5:1, 1958.)

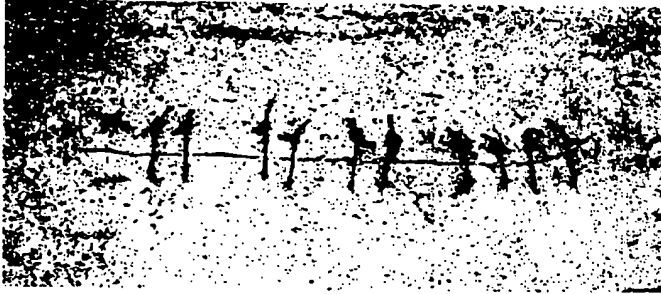
#### *Mattress Sutures*

**Interrupted Horizontal Type.** The interrupted horizontal suture is used quite frequently. It complements the simple interrupted suture in achieving a slight eversion of the skin borders. In Figure 4-5 these sutures are shown in white. As a rule, mattress sutures are not used in thick, boardlike skin (e.g., forehead, back); they are not needed for good approximation, and they tend to cut through and become embedded.

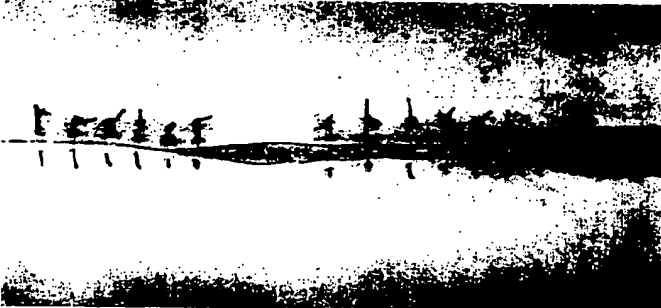
**Interrupted On-End or Vertical Type.** The vertical type of suture is utilized when the skin borders have been undermined for a great distance, or when the subcutaneous tissue has been divided and the surgeon does not wish to place any deep stitches to approximate the deep layers of tissue. The fewer deep stitches, the better; they are a source of foreign-body reaction. This stitch is generally placed ahead of the simple interrupted ones. A frequent mistake made with this stitch is tying it too tightly in order to bring the skin borders together. Vertical mattress sutures should bring the skin borders closer to each other, but should *not* be tight enough to achieve *complete* coaptation; this is one of the most frequent technical blunders made by surgeons. Final coaptation should be accomplished with the aid of simple interrupted sutures. The mattress suture does some approximation, but the simple interrupted suture should be the last touch. Most of the time vertical mattress sutures are removed before simple interrupted sutures since they have a greater tendency to leave stitch marks and serve their purpose sooner than the simple interrupted suture.



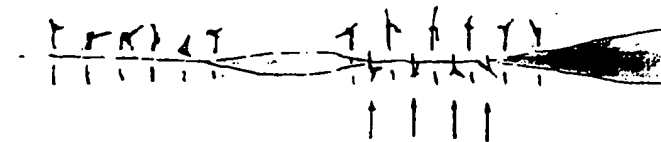
A



B



C



D

FIG. 4-5. Mattress suture techniques. A. Interrupted horizontal sutures (in white), which help to achieve slight eversion of skin borders. B. Interrupted vertical mattress sutures (in white). C. Left, common suture error of using exclusively and tying too tightly the mattress suture for wound border approximation. Right, correctly tied mattress suture. Note that with tension adequate to approximate deep layers, but not so tight that stitch would cut through skin, the skin borders do not coapt. D. On the right can be seen the correct way of completing the skin approximation by using simple interrupted sutures (arrows) in between the mattress sutures.

stitch = suture

The stitch many believe to be the plastic stitch par excellence is the continuous subcuticular suture. It leaves no stitch mark and gives good dermic approximation. However, it does not prevent widening when a wound has a tendency to stretch. It is also time-consuming, and in most instances the results obtained by properly placed simple interrupted sutures are just as good. It is indicated especially when the wound is sutured under considerable tension; such wounds always tend to disrupt, widen, and produce stitch marks. In these cases it is best to use 4-0 monofilament nylon or stainless steel wire in one, two, or even three different subcuticular layers. The splinting effect of this rigid stitch keeps the dermis approximated. The beginning and the end of the continuous intradermal sutures need not be tied, as they do not tend to become loose (Fig. 4-6). Since these sutures do not produce tissue reaction or stitch marks, they can be left in the wound for 10 days, 2 weeks, or longer and can be removed easily (Fig. 4-7). When these multiple-layer intradermal sutures are used, outside sutures (interrupted or continuous) are often used as well to help further in the skin closure.

If the subcuticular suture is used to close very long wounds, it should be brought out on the surface of the skin at intervals of about four cm to facilitate subsequent removal.

*External Continuous Sutures, or Whipstitch.* The external continuous suture is the fastest procedure and may give satisfactory results, although the results are never better than those achieved with the simple interrupted suture. Figure 4-8 shows the simple external continuous suture, which is superior to the locked external continuous suture also shown. The former allows for adjustment once the operation is over.

*The "Baseball" Suture, or Cross-Stitch.* The "baseball" suture is a double continuous suture which, although not qualitatively superior to the interrupted stitch, is faster and

\*suture is separate & distinct from tying continuous suture doesn't require tying of suture

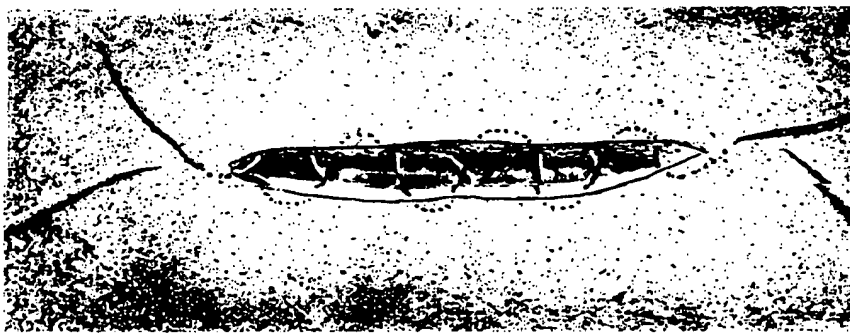


FIG. 4-6. Two layers of continuous subcuticular temporary stitches.

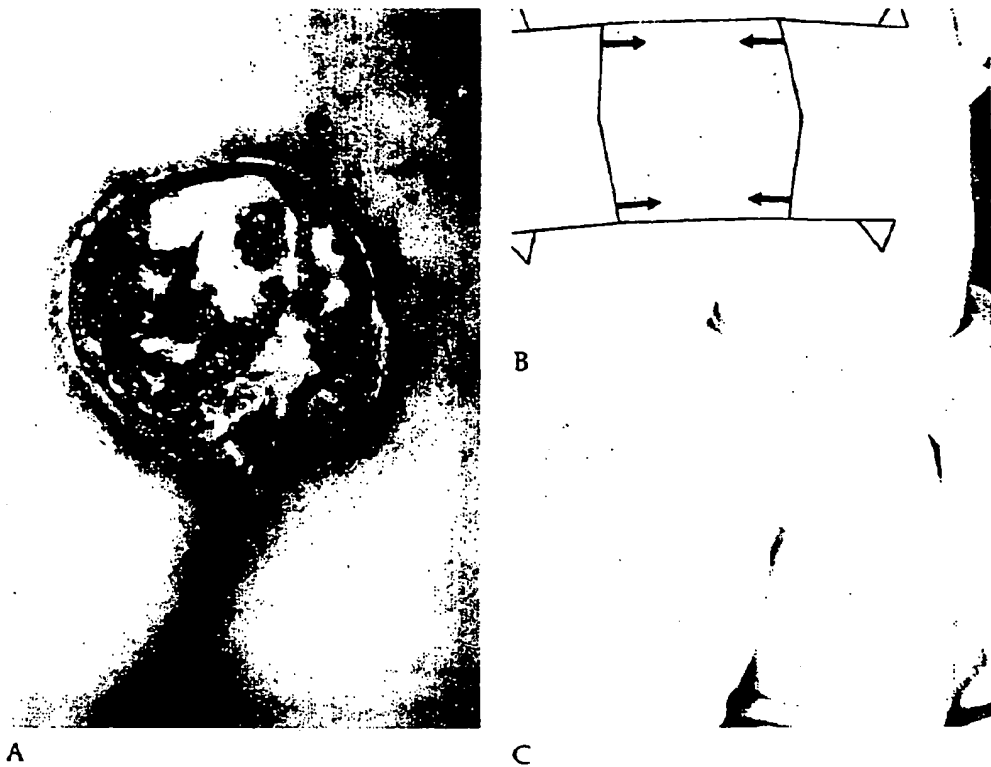


FIG. 4-7. A. Large 5-inch sacral decubitus in a 75-year-old stroke patient. B. Schematic drawing of incisions to be done. To prevent dog ears, four Burow's triangles are excised. C. Final result following closure of defect by bringing together gluteal flaps in straight advancement flap fashion. Meticulous multilayer subcuticular stitching held skin borders together long enough for healing to take place. (From Borges, A. F., *Va. Med. Mon.* 96:651, 1969. Reproduced by permission.)

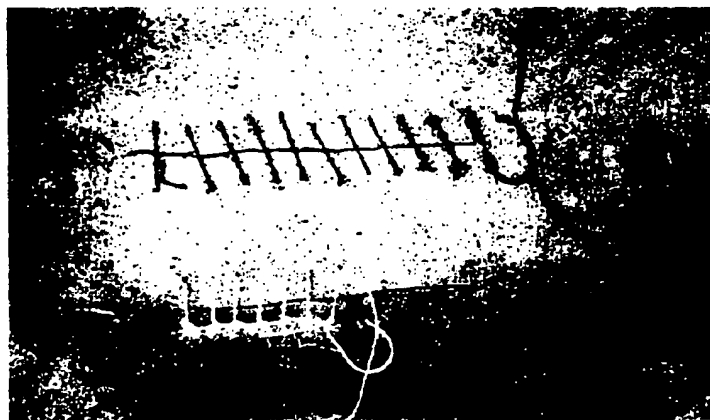


FIG. 4-8. Simple external continuous skin suture at top is better than locked continuous suture below, because it allows for adjustment.

is satisfactory in some situations. Although the author has not previously described it, he has used it with success for five years and regards it as having a place in the surgical armamentarium. It may be used in areas where the skin is thick and when some haste is called for. The "baseball" stitch is done by placing a whipstitch in one direction and completing the closure with the same thread coming as another whipstitch from the other direction (Fig. 4-9). The first row should be loose; the second row is the one that completes the closure. If, after the surgeon has done the first row, the wound seems to be almost completely closed, the returning whipstitch may jump over a number of loops until the starting knot is reached. The thread is tied finally to the long end of the securing starting knot. In the first row of whipstitch, the needle bites deeper and wider into the skin edges than in the second row. The first row is used to approximate the full thickness of the integuments; the second row is more for the purpose of approximating the superficial edge of the wound (Fig. 4-9).

Some experience is required to obtain the best possible result. When placing this

tying  
different  
than  
suturing

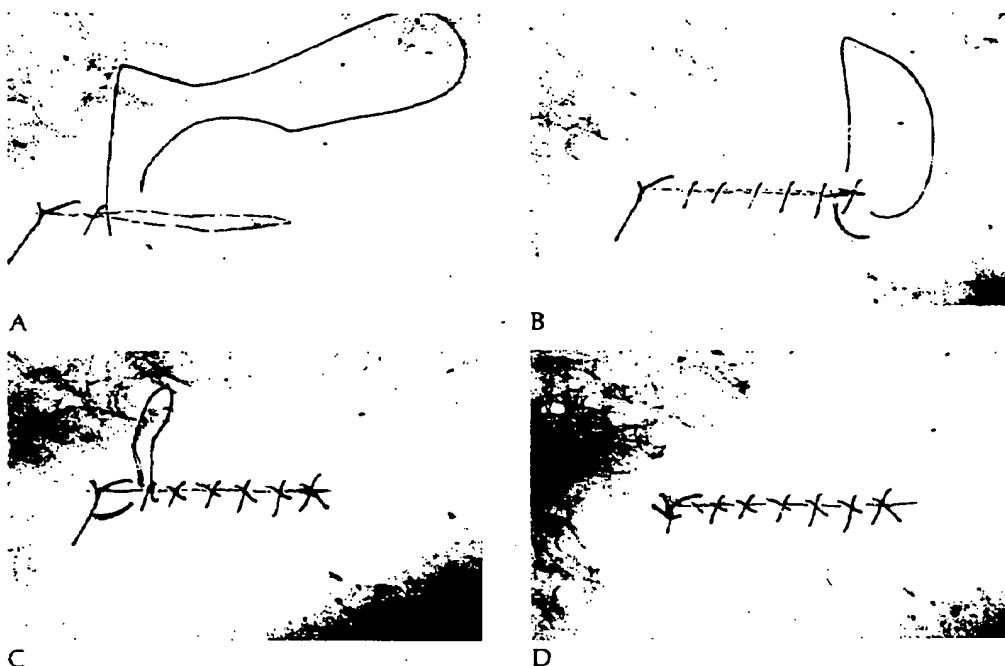


FIG. 4-9. "Baseball," or cross-stitch. A and B. Note slackness of thread in first row. C and D. Second row takes smaller, more superficial bites and completes skin approximation.

X suturing  
bites through tissue

via suturing

Loops &  
knots or  
ties don't  
approximate  
tissue

72

stitch, or any other whipstitch, it is better to make the loops too loose rather than too tight. If the loops are loose, the addition of a few interrupted stitches will complete the skin approximation where the surgeon notes that it is required. If the loops are too tight, there is not much one can do.

suturing does  
Coaptation of Borders

Anatomical landmarks and points of reference created by a wound's irregularities will help bring together tissues into the same relationship they had prior to the laceration. Special care should be given to wounds involving the eyebrows, eyelid margins, nasal ala margins, and the lip's vermilion border. Step-off deformities of these landmarks are very disfiguring.

Some surgeons place hooks at the commissures of the wounds and then pull them apart to bring the skin borders together (Fig. 4-10A). This procedure, which I do not use or recommend, should be utilized only in wounds that faithfully follow the RSTL; in any other wound it will not bring the corresponding segments into correct apposition.

In curved wounds, as shown also in Figure 4-10B and C, skin tension may displace the location of the wound edges—and to such an extent that very great care in suturing is necessary for the approximation to come out accurately.

For approximation of deep tissues I prefer 4-0 chromic catgut, but I do not use even this most of the time. The forceful direct approximation of subcutaneous fat or muscle is not always necessary. Once the skin is well sutured, nature does an excellent job of bringing the deep structures together without the hindrance of deep suture foreign-body reaction. Dermic or subdermic interrupted permanent stitches are also used only when there is great tension. These do not prevent a wound from widening, and they may cause foreign-body reaction.

In deep facial wounds that enter the mouth, the mucosal lining should be sutured; lacerations involving the mucosa *inside* the mouth need not be sutured meticulously to obtain satisfactory healing. The same suture used for the skin may be employed inside the mouth. In children, absorbable Dexon may be used inside the mouth so that the stitches will not need removal.

#### *Handling Skin Borders*

A surgical procedure from beginning to end is full of inevitable trauma. There is really no atraumatic technique; the word is misleading. It would be better to call a delicate technique "hypotraumatic" or "minitraumatic."

It is important to handle all tissue gently. Hooks (Frazier or Tyrell) are the least trau-

*Elective Incisions and Scar Revision*

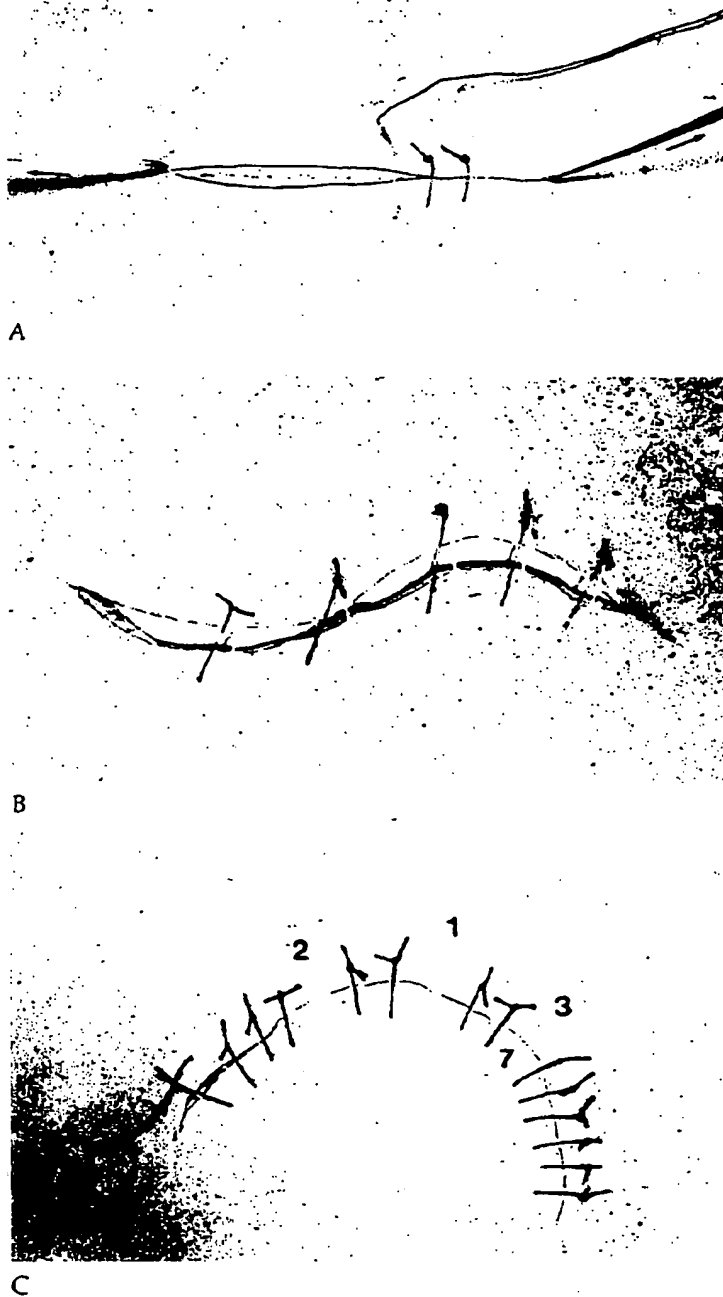


FIG. 4-10. A. Making divergent traction at wound's commissures with skin hooks often does not bring correct corresponding segments of skin borders together except if the wound follows RSTL. B. White sutures perpendicular to wound edges are not correctly placed; dark sutures are. Skin tension tends to dislodge skin borders of irregular or curved ATL wounds. C. Order of placing first three skin sutures in a U-shaped wound.

matizing instruments with which to hold, pull, or separate skin borders (Fig. 4-11A and B). They are not so easy to use as tissue forceps, but dexterity in handling them comes with training and experience. If they are not available, small tissue forceps with teeth are best (Adson) (Fig. 4-11C). Tissue forceps without teeth require more pressure to hold the tissues, and they traumatize more than those with teeth. Oftentimes the practiced surgeon may find it unnecessary to hold the skin border with any instrument when passing a stitch. The first skin border is held in place by the underlying structures; the second skin border is held by the skin tension, aided by a gauze sponge (Fig. 4-12).

When it is necessary to pull on a skin border frequently or for a long time, it is advisable to use temporary retraction sutures rather than hooks. These sutures are loosely tied and will not tend to come out if an end slips off the forceps holding them. Allis tissue forceps should not be used as skin retractors.

## PROPHYLAXIS OF WOUND INFECTION

### *Cleansing the Wound*

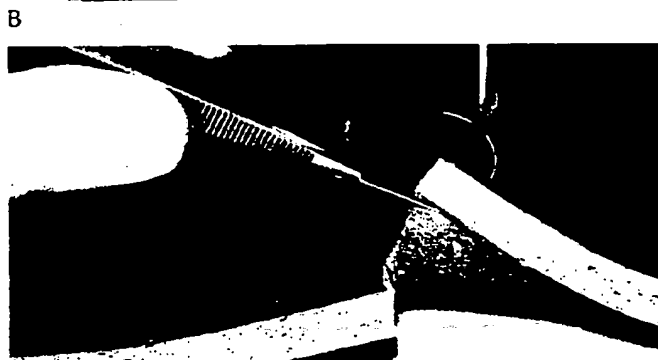
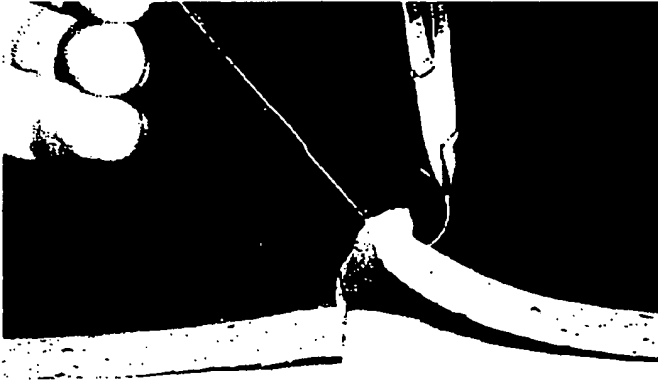
Lacerations should be cleansed thoroughly to prevent infection. The skin of the area should be cleansed with soap and water; hair in the immediate neighborhood should be shaved, with the exception of eyebrow hairs, which are spared. They are important landmarks for exact tissue approximation. Moreover, the wound may heal in a week, while the eyebrow takes much longer to grow back.

While the skin is cleansed, the wound should be packed with sterile gauze to protect it from the cleansing agent. The eyes should be protected with an ointment. A strong antiseptic can be used only over normal skin; it should not be used in the wound. Chemicals effective in killing bacteria within the wound will further damage the already traumatized tissue. Instead of preventing infection, they favor infection by lowering the local defense mechanism of the tissues involved.

Ingrained dirt may require scouring; otherwise, the scar may be tattooed. This complication is relatively easy to prevent, but difficult to correct.

The wound itself is best cleansed by thorough irrigation with normal saline solution. Mechanical swabbing with gauze soaked in saline, along with the force of irrigating saline, is sufficient to remove surface wound contaminants and any completely detached fragments of tissue. While the skin borders are raised with hooks, the depth and crevices of the wound are flushed with a 5- or 10-cc syringe. The same syringe used for the local anesthetic can be used for this purpose. Plungerless bulb syringes take a long time to fill up, and the water flows with insufficient pressure. Although such a syringe uses much more water, it does not cleanse so well.

### *Elective Incisions and Scar Revision*



suturing

FIG. 4-11. A and B. Inserting needle through skin borders with aid of skin hook. C. Inserting needle utilizing teeth of one side of tissue forceps as hook; other side is not pinching skin.

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MASTERY OF SURGERY

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Mastery of  
Plastic and  
Reconstructive  
Surgery

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Volume 1

Mimis Cohen

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MASTERY OF SURGERY

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# Mastery of Plastic and Reconstructive Surgery

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Volume I

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ministered, the vascularity of the site of injection, the speed of injection, and the presence or absence of epinephrine. The balance between drug absorption, distribution, and elimination is upset. Different drugs possess different relative toxicities. More vascular sites allow more rapid drug absorption. The most common cause of toxicity, however, is unintentional intravenous injection. A drug overdose is the most common cause of death.

The signs and symptoms of CNS toxicity parallel the serum concentration of the anesthetic agent. This dose-related spectrum of cerebral effects follows a classic increasing order of severity:

1. Circumoral and tongue numbness, metallic taste
2. Lightheadedness
3. Tinnitus
4. Visual disturbances (diplopia, nystagmus)
5. Anxiety, slurring of speech, irrational behavior
6. Muscle twitching
7. Convulsions (grand mal)
8. Unconsciousness
9. Coma
10. Respiratory arrest
11. CNS depression

Myocardial toxicity may cause hypotension, bradycardia, and, eventually, cardiac standstill. The mechanisms of action include slowing of myocardial conduction, myocardial depression, and peripheral vasodilatation. The effect is usually seen clinically only after injection of two to four times the convulsant dose.

Problems with local anesthetic toxicity can be prevented by observing several simple rules.

1. Always use the recommended dose.
2. Before injecting the drug, aspirate the area with the needle in position to prevent intravenous injection.
3. When a local anesthetic contains epinephrine, intravenous injection produces a brief tachycardia 30 to 45 seconds after injection. Watch for this signal.
4. When administering large quantities of local anesthesia, give drugs of low toxicity slowly in several small aliquots.
5. Maintain continuous verbal communication with the patient during drug

administration. It provides the earliest clues to CNS toxicity.

6. Watch for minor symptoms, which can be seen before the drug is entirely given.

Before a local anesthetic agent is injected, all necessary resuscitation equipment and drugs should be available. As soon as toxicity is recognized, one should proceed with the ABCs of resuscitation—establish and maintain a clear *airway*; give oxygen to prevent hypoxia (*breathing*); and administer intravenous fluids and drugs for hypotension and bradycardia (*circulation*). If convulsions occur and they persist for more than 20 seconds, an anticonvulsant such as diazepam, 5 to 20 mg, or thiopental, 50 to 100 mg, should be given intravenously.

### Suturing Skin Wounds

Surgical wound closure should be harmonious with biologic events, such as fibroplasia, epithelization, wound contraction, bacterial balance, and host defense mechanisms. It is important to consider each suture a foreign material that evokes a tissue inflammatory reaction, which can cause delayed wound healing, infection, or dehiscence. All suture materials, including the absorbable and nonabsorbable monofilaments, incite some degree of inflammatory response, and one must be discriminating in the selection and placement of suture material. The selection of suture material should be based on the healing properties and requirements of the involved tissue, the biologic and physical properties of the suture material, the location on the body, and patient considerations.

### Suture Material

The choice of suture material is critical in the early stages of wound healing because the suture is primarily responsible for "keeping the wound together." In the first 3 to 4 days after wounding, the tensile strength of the skin increases as fibrin clot fills the wound cavity. One week after wounding the tensile strength of the skin is less than 5 percent that of unwounded skin; it is 10 percent after 2 weeks, 25 percent after 4 weeks, and 40 percent after 6 weeks, never achieving more than 70 to 80 percent of normal unwounded tensile strength. Thus the use of absorbable der-

mal sutures, such as polyglactin 910, polyglycolic acid, and polyglyconate, which lose their tensile strength in the first several weeks, when wounds are still very weak, can cause spreading and even dehiscence of wounds. In fact, studies show no significant improvement with dermal sutures over cutaneous sutures alone. The finest scars are seen when a subcuticular monofilament suture material is left in place for several weeks or even months.

Skin margins should always be everted and approximated without tension. After a knot is tied, the suture appears pear-shaped in cross section with raised borders. The everted skin edges gradually flatten to produce a level surface. It is important to place the suture so that the wound edges just touch each other. Post-operative edema produces additional tension with resultant strangulation of tissue and ischemia, leading to necrosis. A layered closure with subcuticular sutures should be performed with knots tied snugly but not so tight as to cause strangulation of tissue by necrosis.

There are many different methods of skin suturing. These include simple interrupted, vertical and horizontal mattress, continuous subcuticular, half-buried horizontal mattress, and continuous over-and-over suturing (Fig. 2-5). Simple interrupted sutures are inserted so that the needle enters and exits the tissue at the same angle, grasping identical amounts of tissue to approximate the wound margins exactly. Vertical mattress sutures produce excellent eversion of the skin edges. Horizontal mattress sutures provide good approximation of the skin edges with some eversion. They usually cause more skin ischemia than either simple interrupted or vertical mattress sutures. Subcuticular or intradermal continuous sutures eliminate the need for interrupted skin sutures, avoid suture marks on the skin, and produce the most favorable scar. These continuous sutures should be left in place for several weeks. Polypropylene is most commonly used for this purpose because it produces little inflammatory reaction, maintains its tensile strength, and can be removed easily. Half-buried mattress sutures are especially useful for closing V-shaped wounds or approximating skin edges of different textures and thicknesses. Using these sutures often prevents the necrosis of the tip

dehiscence = disruption

knot tying operation

penetrate wound

suture responsible for keeping wound together

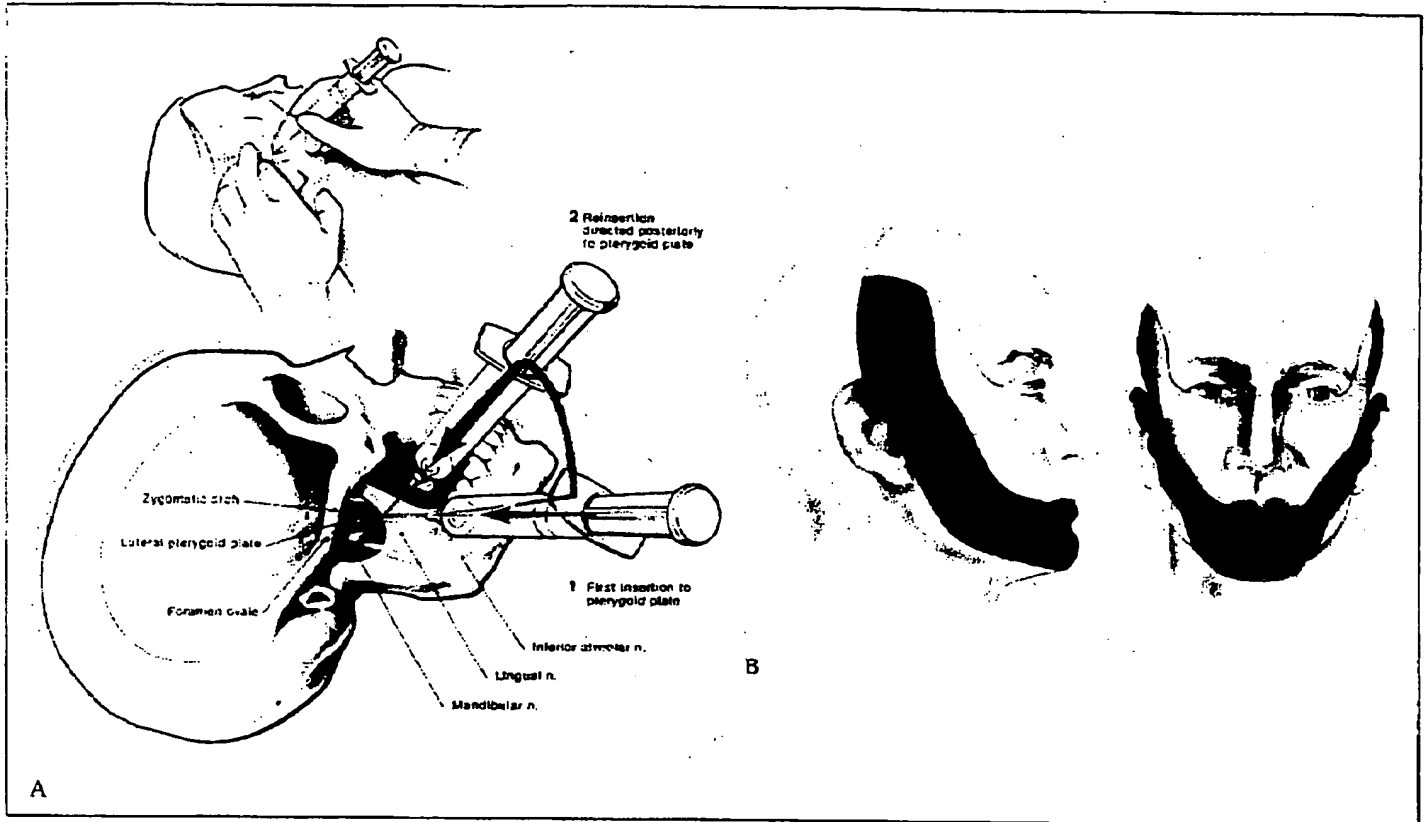


Fig. 2-5A. Mandibular nerve block. B. Sensory distribution of mandibular nerve. (Part A from J. Katz [Ed.], *Atlas of Regional Anesthesia*. [2d Ed.]. Norwalk, Connecticut: Appleton and Lange, 1994. Reproduced with permission; and Part B from D.L. Brown [Ed.], *Atlas of Regional Anesthesia*. Philadelphia: W.B. Saunders, 1992. Reproduced with permission.)

of the V that occurs with simple interrupted sutures. When the buried portion of the suture is placed within the dermis of the flap, ischemia and damage to the overlying skin are avoided. Continuous over-and-over sutures are most often used in closure of scalp wounds, where they can be rapidly performed and are hemostatic. Last, immobilization of the wound is as important in soft tissue healing as it is in bone healing; it can be achieved with sterile adhesive strips, tapes, collodion, or even plaster splints.

Different types of suture material are currently available for wound closure. These suture materials can be classified as natural or synthetic, absorbable or nonabsorbable, and braided or monofilament. Additional classification takes into consideration the time of absorption, amount of tissue reaction, and tensile strength (Table 2-2).

Absorbable suture material includes catgut, polyglactin 910, polyglycolic acid, polydioxanone, polyglyconate, and silk.

Catgut is derived from the submucosal layer of sheep intestine. It evokes a moderate tissue reaction and is digested by the body's proteolytic enzymes within 60 days. Tensile strength is rapidly lost within 7 to 10 days. Chromization of the catgut suture slightly prolongs the time to loss of tensile strength and digestion. The main uses of catgut sutures include ligation of superficial vessels and closure of tissues that heal rapidly, such as the oral mucosa. Catgut also may be used in situations in which one does not want to remove the sutures, such as wounds of small children or a nipple-areolar inset after breast reduction. However, the use of catgut may incite more tissue reaction than desired.

Polyglactin 910 and polyglycolic acid are synthetic materials that behave similarly. They produce low tissue reactivity and are completely absorbed by hydrolysis within 90 days. Tensile strength is 60 to 70 percent at 2 weeks and is lost at 1 month. Both materials are useful as in-

tradermal sutures because of their low reactivity, but one should be discriminating about using them for buried sutures. They have a tendency to "spit" with inflammation. When polyglactin 910 and polyglycolic acid are used as cutaneous sutures, scar widening may occur. The sutures should be removed 7 days after placement, before sinus tracts form. The braided configuration of these materials may potentiate infection; therefore, these materials should not be used in wounds with bacterial contamination.

Polydioxanone (PDS) is a synthetic absorbable monofilament suture that is minimally reactive and absorbed by hydrolysis over 6 to 9 months. Because of this very slow absorption, "spitting" is a considerable problem. Because the material is a monofilament, there is less affinity for bacterial seeding. This suture material maintains its tensile strength considerably better than the materials previously mentioned. Fifty percent of its original strength remains 4 weeks after suture

Table 2-2. Types of suture materials

Suture	Type	Raw material	Tensile strength	Absorption	Tissue reaction
Catgut	Plain	Submucosal layer of sheep intestine; serosal layer in cattle; flexor tendon	Lost within 7-10 days	Digested by body proteolytic enzymes within 60 days	Moderate
Catgut	Chromic	As above. Treated by chromization to resist digestion by body tissues	Lost within 3-4 weeks	Digested by body enzymes within 90 days	Moderate (less than plain catgut)
Polyglactin 910	Braided	Polymer of glycolic acid	60% remains after 2 weeks 30% remains after 3 weeks Lost within 1 month	Minimal until day 40. Absorbed by slow hydrolysis. Complete in 60-90 days	Mild
Polyglycolic acid	Braided	Polymer of glycolic acid	Lost within 30 days	Complete digestion within 90 days	Mild
Polydioxanone	Monofilament	Polyester filament	70% remains after 2 weeks 50% remains after 4 weeks 25% remains after 6 weeks Lost within 1 year	Minimal until day 90. Absorbed by slow hydrolysis. Complete digestion within 6-9 months	Mild
Silk	Braided	Natural protein spun by silkworm	Lost within 1 year	Complete by 2 years	Moderate
Nylon	Monofilament	Polyamide polymer	Loses 15-20% per year	Degrades at 15-20% per year	Very low
Nylon	Braided	Polyamide polymer	Loses 15-20% per year	Degrades at 15-20% per year	Very low
Polyester	Braided	Polyester polyethylene terephthalate coated with polybutylate	Indefinite	Nonabsorbable; encapsulated in body tissues	Minimal
Polypropylene	Monofilament	Polymer of propylene filament	Indefinite	Nonabsorbable; encapsulated in body tissues	Minimal transient acute inflammation

placement, and 25 percent remains 6 weeks after placement. Polydioxanone completely loses its strength one year after the operation. Polyglyconate is an absorbable monofilament suture with the qualities and advantages of PDS; however, it retains its tensile strength for only 3 to 4 weeks.

The nonabsorbable monofilament (nylon and polypropylene) and braided (nylon and polyester) suture materials cause minimal inflammatory reaction, slide well, and can be removed easily, thus providing an ideal running intradermal stitch. Polypropylene appears to maintain its tensile strength better than nylon, which loses approximately 15 to 20 percent of its original strength per year.

Staples provide less inflammatory reaction than sutures, have similar strength up to 21 days, and leave a similar ap-

pearance to sutured wounds when removed by one week after the operation. Large wounds can be closed faster and more expeditiously with staples. Staples are useful for procedures such as large flaps, abdominoplasty, mammoplasty, and skin grafting. One must remember, however, to remove the staples early to avoid permanent suture marks.

The formation of permanent suture marks depends on the length of time a skin suture remains in place, the tension on the wound margins, the region of the body, the presence of infection, and the tendency of the patient for hypertrophic scarring or keloid formation. The most critical factors in avoiding suture marks in the skin are tension-free closure and early removal of sutures. These two factors are far more important than either the size or the type of suture material. Generally sutures left in place for 14 days

cause severe scarring with cross hatching. Wounds from which sutures are removed within 7 days produce a fine linear scar. Wound closure with a running derma pullout suture provides an optimal scar without interfering with the development of tensile strength. The finest sutures for any given wound should be used. Suture should be removed at different times from different areas of the body. This period ranges from 3 to 5 days for the face to 10 to 14 days for the limbs.

### Elective Surgical Wounds

The quest for the optimal scar is a formidable one. The ultimate goal sought by the plastic surgeon is a fine, flat, concealed linear scar lying within or parallel to a skin wrinkle or natural skin line, contour junction, or a relaxed skin tension line. There should be no irregularity in contour or distortions of adjacent areas.

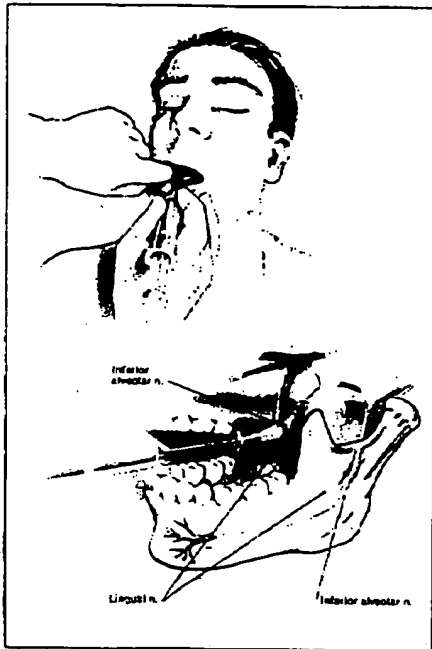


Fig. 2-6. The lingual nerve block is usually performed in conjunction with the inferior alveolar nerve block. (From J. Katz [Ed.], *Atlas of Regional Anesthesia*. [2d Ed.]. Norwalk, Connecticut: Appleton and Lange, 1994. Reproduced with permission.)

atomic units or landmarks. Changes in pigmentation should be avoided.

Elastic fibers within the dermis maintain the skin in a state of constant tension. This fact can be appreciated by the gaping of wounds made by incising the dermis or by the immediate contraction of skin grafts as they are removed from the donor site. Langer, in 1861, demonstrated that puncturing the skin of cadavers with a rounded sharp object made elliptic holes produced by the tension of the skin. He stated that human skin was less distensible in the direction of the lines of tension than across them. The use of the Langer lines has the following shortcomings: (1) Some tension lines were found to run across natural creases, wrinkles, and flexion lines; (2) the lines exist in excised skin; and (3) they do not correlate with the direction of orientation of dermal collagen fiber. Nonetheless, the Langer lines serve as a useful guide in the planning and design of skin excisions.

Scars are least conspicuous when they follow any skin line, preferably a wrinkle or natural skin line, a contour line, or a line

of dependency (Fig. 2-6). Relaxed skin tension lines, also known as wrinkle lines, natural skin lines, lines of facial expression, or lines of minimal tension, lie perpendicular to the long axis of the underlying facial muscles. They are accentuated by contraction of the muscles, as by smiling, frowning, grimacing, puckering the lips, or closing the eyes tightly. On the face, wrinkle lines or lines of facial expression develop in a predictable pattern with age. At about the age of 30 years, upper eyelid redundancy and the fine, lateral orbital laugh lines known as crow's feet develop. By the age of 40 years, periorbital and nasolabial folds deepen and glabellar and forehead wrinkles occur. Wrinkling in the neck and drooping of the tip of the nose appear between the ages of 50 and 60 years. With progressive aging, the facial skin becomes thinner and the wrinkles more prominent. These changes are accompanied by wasting of adipose tissue in the temporal and buccal regions. Wrinkle lines in other parts of the body can be seen by flexing and extending that part of the body.

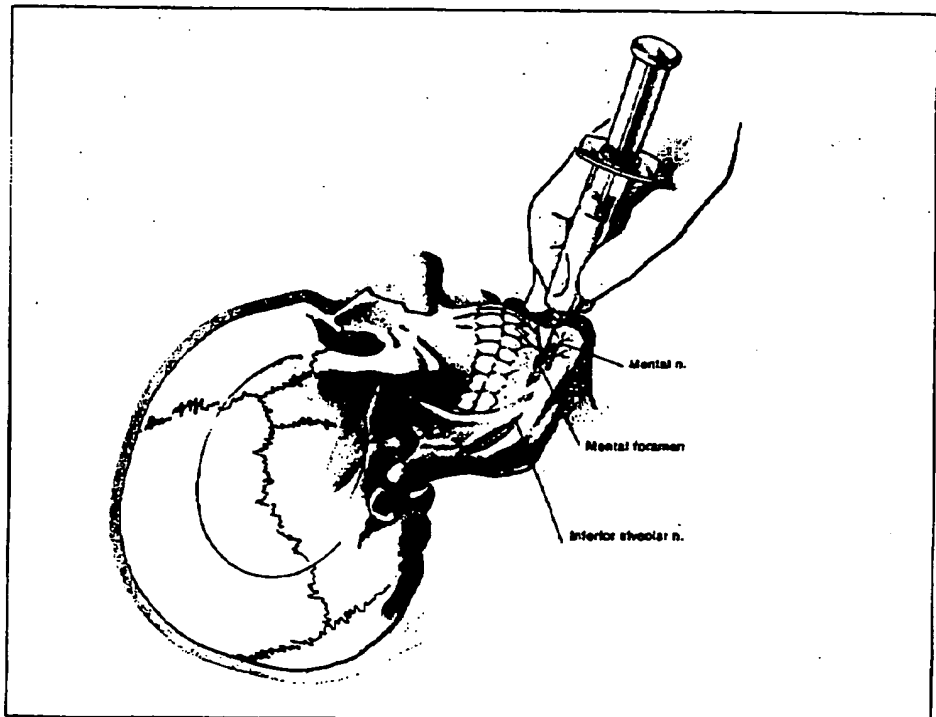
Scars placed within relaxed skin tension lines or parallel to them are subjected to

minimal tension during the period of healing because they are not subjected to the intermittent pull of the subjacent muscles. Contour lines occur at the junction of body planes, such as the juncture of the nose with the cheek, the juncture of the cheek with the neck skin in the submandibular region, and the inframammary fold. Lines of dependency occur in older people as a result of the effects of gravity on the loose skin and fatty tissue. Jowl lines and "turkey gobbler" folds in the neck are classic lines of dependency. Cross-hatching patterns in the face are caused by the intersection of the lines of dependency and the lines of facial expression.

## Principles of Wound Closure

Skin lesions may be removed by elliptic, wedge, or circular excisions. Most skin lesions are removed by a simple elliptic excision with the long axis of the ellipse on or paralleling a wrinkle or natural skin line, a contour line, or a line of dependency (Fig. 2-7). The ellipse may be lenticular and have angular or rounded

Fig. 2-7. The mental nerve can be anesthetized transcutaneously or transorally as it exits the mental foramen. (From J. Katz [Ed.], *Atlas of Regional Anesthesia*. [2d Ed.]. Norwalk, Connecticut: Appleton and Lange, 1994. Reproduced with permission.)



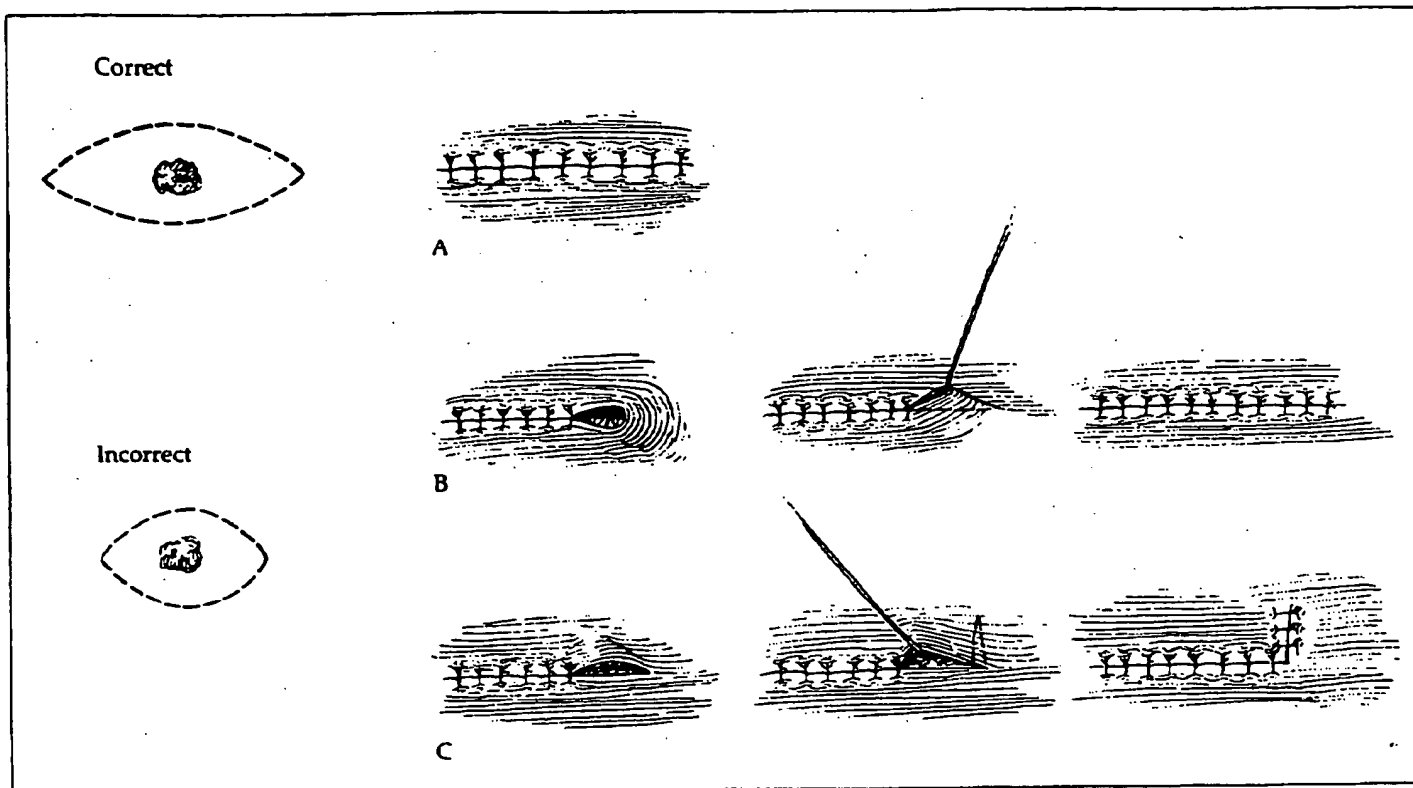


Fig. 2-8A. Ideally an ellipse should be planned so that the long axis is about four times longer than the short axis. Dog-ears form at the ends of a closed wound when either the ellipse is made too short or one side of the ellipse is longer than the other. The dog-ear may be corrected by either fusiform extension of the elliptic excision (B) or a short, right-angle incision at the end of the ellipse with removal of the redundant skin (C).

edges. Ideally, the long axis should be four times longer than the short axis. If this ratio becomes smaller, bunching of excess skin causes a dog-ear. Dog-ears occur when there is a considerable discrepancy between the two sides, one side approaching a semicircle and the other almost a straight line. Dog-ears may flatten over time, but it is best to excise them primarily. There are two methods for eliminating a dog-ear. (1) If the elliptic excision is too short, one can either lengthen the ellipse to include the excess tissue or excise the redundant tissue as two tiny triangles. (2) If the dog-ear has occurred because one side of the incision is longer than the other, one can correct the problem by making a short right-angle or 45° incision at the end of the ellipse (Fig. 2-8).

Large lesions can be removed by multiple serial excisions. The principle takes into account the viscoelastic properties of skin and use of the creep and stress relaxation phenomenon. It has been especially use-

ful for improvement of male pattern baldness by excision of the non-hair-bearing areas of the scalp. With the introduction of soft tissue expansion, however, the technique of serial excision has become less popular.

Wedge excisions are performed primarily for lesions occurring on the free margins of the ears, lips, eyelids, or nostrils. Lesions of the lip can be excised as either triangles or as pentagonal wedges. Excision of lesions occurring in these locations as a pentagon often causes less contracture and shortening along the longitudinal axis of the incision and a more favorable scar than does excising the lesion as a triangle (Fig. 2-9). Closure of circular defects can be performed by a skin graft, by sliding V-Y subcutaneous pedicle flaps, or by hatchet-type transposition or rotation flaps (Fig. 2-10).

Fig. 2-9. Wedge excision of lesions on free margins of the lip, the rim of the nostril, and the lower eyelids.

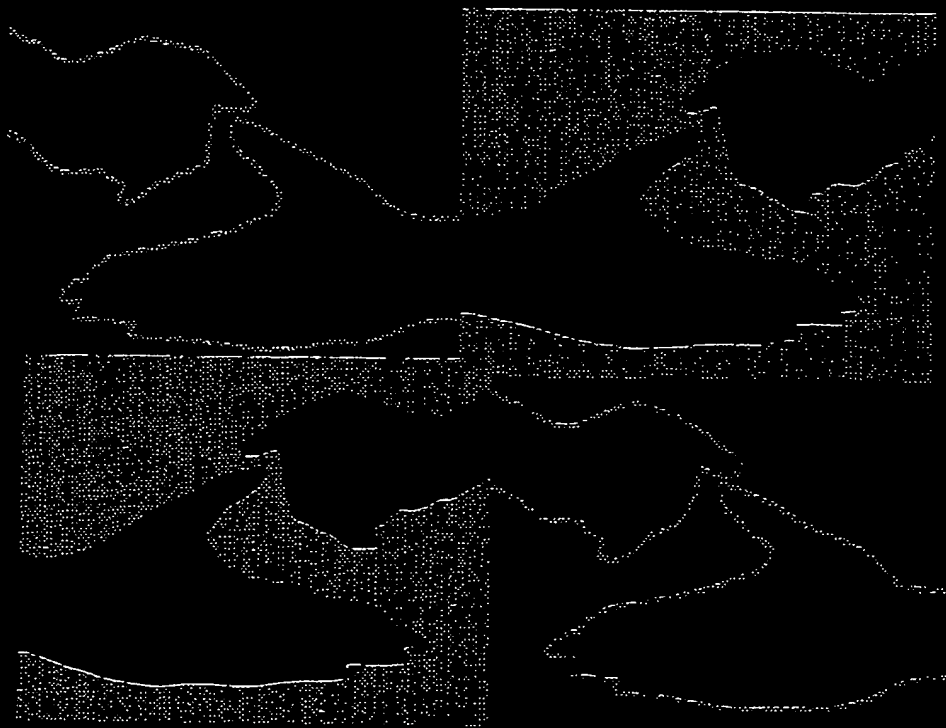


Third Edition

# The Hand

DIAGNOSIS AND INDICATIONS

Graham Lister



CHURCHILL LIVINGSTONE

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# **The Hand: Diagnosis and Indications**

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**Graham Lister**

THIRD EDITION



**CHURCHILL LIVINGSTONE**  
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**CHURCHILL LIVINGSTONE**

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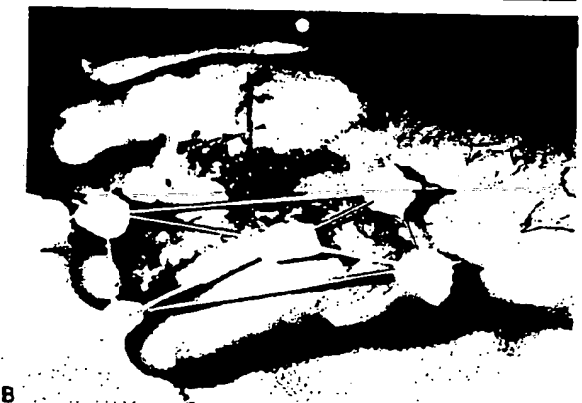
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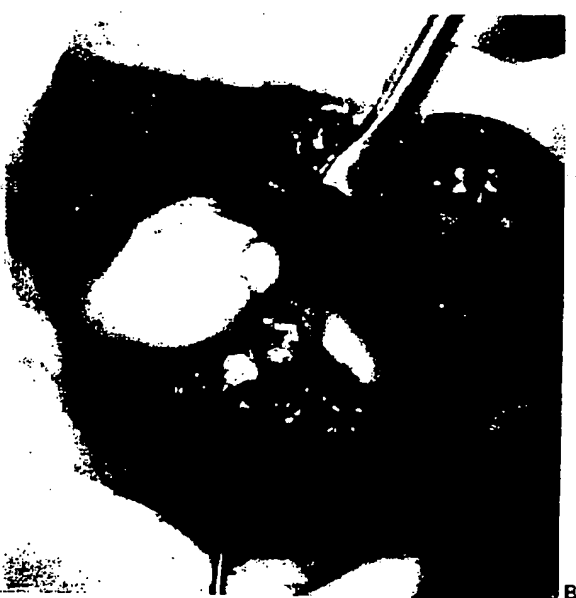
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## 98 THE HAND: DIAGNOSIS AND INDICATIONS



**Fig. 1.143** A. Following a gunshot wound this patient had a significant segmental loss of the third and fourth rays. B. The length was maintained at the time of the initial debridement by the use of Kirschner wires 'spot welded' with methyl methacrylate.

anatomy and by locating and matching the articular facets on each. Reduction is often facilitated by applying finger trap distraction and is further aided by repeated study of the radiographs (Figs 1.127, 1.137) (see p. 96).



**Fig. 1.144** A. Radiographic examination of this patient, who sustained a game-keeper's thumb, revealed a suspicious fragment on the palmar aspect of the joint. B. Exploration of the joint revealed not only a fracture fragment from the anterior lip of the proximal phalanx, but also a depressed condylar fracture of the radial aspect of the metacarpal head.

## INJURY 99

**Tendon and muscle**

In the tidy hand injury, fairly firm conclusions will have been made about which tendons have been lacerated during the initial examination. These conclusions should be confirmed at exploration. The problems then remaining concern distinction of tendon from nerve, matching of tendon ends and exposure in the digit.

**TENDON OR NERVE?**

Locating the ends of divided structures for identification, matching and suture can be a frustrating exercise. Clearly, flexing the wrist and fingers fully will help to bring the ends towards the wound but then, even with retraction, the ends may be obscured by blood clot. Herein lies the solution. By dissecting where the clot is most dense and pure, the ends will be revealed as white gleams through the gore (Fig. 1.145). Working in this bloodstained synovium is like wading through quick-

sand. Rather it should be excised sharply, revealing the contained structures, which can be identified by:

*Colour.* Tendon: whitish yellow; nerve: whitish grey.

*Texture of the surface.* Tendon: smooth and firm; nerve: softer and somewhat more irregular due to the fascicular bundles appearing as longitudinal strands.

*Median artery.* If the structure believed to be the median nerve is inspected closely with magnification, an artery of differing diameter will almost always be found on its surface. Both nerve ends can be so identified. The artery also serves to ensure that the correct orientation of the nerve ends is selected for repair.

*Retraction.* Nerve ends retract much less than do divided tendons.

*Nerve fascicles.* After irrigation, if the nerve end is turned end-on and inspected with magnification, the fascicular bundles can be seen, shiny and hemispherical.

*Passive movement.* Selective flexion of the digital joints will identify individually the *distal* tendons ends. Once

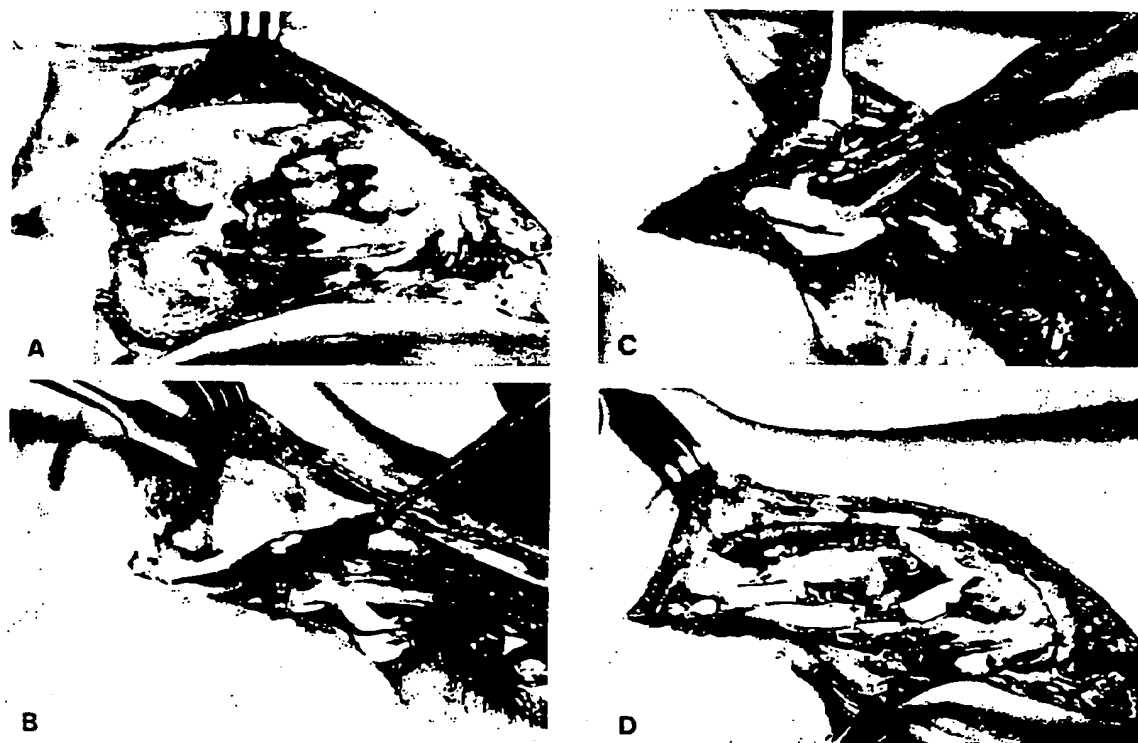


Fig. 1.145 A. This patient had sustained a clean laceration of the palmar aspect of the wrist. The proximal tendon ends had been retrieved with little difficulty, but even with full finger flexion the distal tendon ends were obscured in the dark blood clots seen at the proximal end of the carpal tunnel (on the left of the photograph). By dissecting where the blood clot was most dense (B, C), the distal tendon ends were revealed as a white gleam through the synovium. After transfixing the tendons with straight needles they were suitably approximated for subsequent primary tendon suture (D).

suturing

## 100 THE HAND: DIAGNOSIS AND INDICATIONS

the *proximal* ends have been identified with a high degree of confidence, grasp them in turn by the cut end with fine toothed forceps and pull gently. A characteristic gliding motion will result and often the muscle belly will be revealed.

## FLEXOR TENDON IDENTIFICATION AND PREPARATION

*At the wrist: distal ends*

In multiple flexor tendon injuries at the wrist, identification of the distal ends is straightforward after they have been located, profundus tendons flexing the distal interphalangeal joint, superficialis tendons the proximal interphalangeal joint. Traction on the distal end should be performed with the same care as on the proximal end by grasping the cut tendon end with fine toothed dissecting or mosquito forceps in order to avoid damage to the outer surface of the tendon (Fig. 1.146). Pulling on any finger flexor at the wrist, but especially a profundus tendon, will produce flexion to a varying degree in fingers adjacent to the finger to which the tendon goes, due to the interconnections between the tendons and due to the common synovial sheath. This spurious movement can be distinguished from that in the correct finger by gently resisting the pull with a finger on each digital pulp in turn. In the correct finger there is a precise transmission of pull from tendon to finger tip compared with the 'dampened' pull in the adjacent finger.

*Proximal ends*

The correct matching of the proximal ends at the wrist is rather more taxing as all pass through the space which occupies only 3 cm to the ulnar side of the median nerve. Four features aid in identification:

*Anatomy.* The finger flexor tendons lie in three layers:  
*superficial:* flexor digitorum superficialis to middle and ring (Fig. 1.147)



Fig. 1.146 Traction on the distal tendon end will effect flexion of either the proximal or the distal interphalangeal joint thereby revealing, as here, a flexor digitorum superficialis.

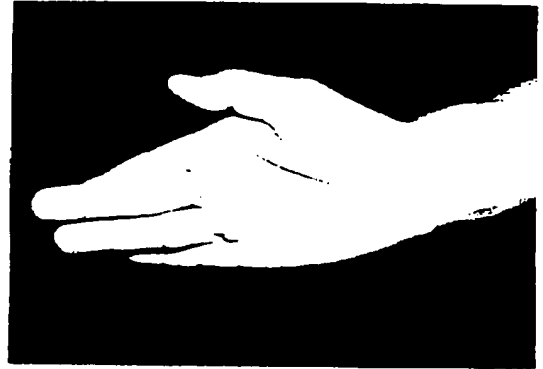


Fig. 1.147 In this posed photograph, the relationship of the superficialis tendons at the wrist is demonstrated. Those to the middle and ring fingers lie superficial to those to the small and index fingers.

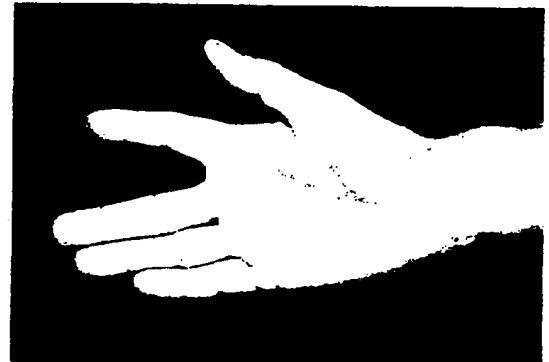


Fig. 1.148 All of the profundus tendons lie in the same plane. Those to the middle, ring and small fingers are, however, conjoined at the wrist, arising as they do from a common muscle belly while that to the index finger is quite separate.

*middle:* flexor digitorum superficialis to index and small

*deep:* flexor digitorum profundus to all fingers; those to middle, ring and small are conjoined; that to index is separate (Fig. 1.148)

*Cross-section.* No two tendons have identical cross-section, either in diameter or shape.

*Angle of cut.* Despite the fact that all have been injured by the one blow it is surprising how the angle of the cut varies. This also affects the cross-sectional appearance.

*Length.* If the tendon ends are brought into exact apposition with no gap or overlap and held there, ready for suturing, by transfixion of the tendon ends with straight needles, the normal balanced posture of the

\*  
 suturing.



Fig. 1.149 The patient whose hand is illustrated in Fig. 1.145 had sustained an oblique laceration. After approximation and repair of the tendon ends it is evident that the correct proximal end was selected by the positioning of the fingers which lie in the normal cascade, the relationship of the fingers one to another being that which is seen in the uninjured hand.

finger should result (Fig. 1.149). Standard hypodermic needles should be used for this task for they are sharp and they inflict little damage; also, because of their hub, they cannot stray or be forgotten.

While describing retrieval of proximal tendon ends, an anatomical point should be made with regard to the flexor carpi radialis. It lies neither above the fascia nor below it but rather within it, in its own separate tunnel. If the surgeon remembers this he will retrieve it either by looking for the tunnel end-on, where it will be marked by tell-tale blood clot, or he will seek it from above or below the fascia where the tendon will shine through and can be released by incision.

#### *In the digit*

Having extended the incision as required to expose the distal end as dictated by the posture of the hand at the time of injury (p. 4) the flexor tendon sheath is exposed. Current theory and increasing practice dictate that the sheath should be preserved and repaired after flexor tendon repair<sup>465,466</sup>. Sheath repair is relatively easy in its retinacular or cruciate portions and rather difficult in the annular pulleys. The latter should therefore be preserved intact whenever possible. With this in mind the cut end of the distal tendon should be located by looking through the sheath while flexing the finger. It will be seen as a moving junction of white tendon and dark red blood. The length of this tendon, which can be seen in the retinacular portion of the sheath with full flexion, is then measured (Fig. 1.150):

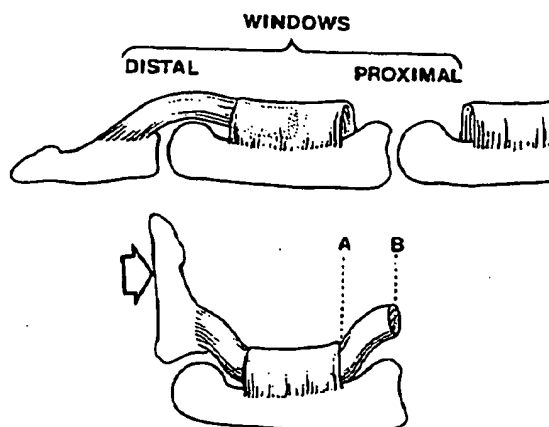


Fig. 1.150 Assessment for exposure during flexor tendon repair (see text).

#### AB

1 cm or more

The entire tendon repair can be done by opening a 'window' in that retinacular portion of the sheath — a proximal window repair<sup>467</sup>.

0.5 to 1 cm

The 'core' suture (Mason-Allen, modified Kessler etc.) cannot be placed in the distal tendon end through that window, so both it and the next window distally must be opened — a combined window repair.

less than 0.5 cm

Even the peripheral running suture cannot be inserted through that window so that the major part of the work must be done in the next window — a distal window repair.

If the superficialis is lacerated over the proximal phalanx where its two parts are wrapping around the profundus to reach their insertion, care should be taken to recognize the sinister effects of the *superficialis spiralis*<sup>468</sup>. After complete laceration the spiral unwinds so that both ends move from their correct orientation which is in the sagittal plane to lie in the coronal plane of the finger. The problem arises because the two ends unwind in opposite directions. If repaired as they lie, where the flat ends, when approximated, look deceptively correct, the smooth tunnel they formerly created for the profundus will be grossly distorted.

#### EXTENSOR TENDONS

The *distal ends* can be identified by the action produced on traction, bearing in mind the effect of the intertendinous connections.

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Fig. 1.151 In this clean-cut laceration of all the extensor tendons at the wrist, the variation in cross-sectional dimension, in angle of cut and in the length of the various tendons can be seen.

The *proximal ends* can be classified into groups if they remain in their compartment beneath the extensor retinaculum or if they can be replaced there with confidence by tracing them into the sheath from which they have retracted. Which tendons come through which compartment can be recalled by using Table 1.1 (p. 16). Further identification depends, as with the flexor tendons, on studying:

cross-section  
angle of cut  
length (Fig. 1.151).

## PARTIAL DIVISION OF TENDONS

This may not have been revealed on examination (p. 30) but may subsequently result in tendon rupture if not repaired. Where some tendons have been totally divided this gives a strong clue as to the site of any partial divisions inflicted on others. Partial divisions of tendons should be sought by inspecting each tendon in the vicinity of the skin wound along as much of its length as can be delivered into the wound by full flexion of all joints with traction alternately directed both proximally and distally. The traction should be exerted by gripping the tendon with a gauze swab moistened with saline or by the use of a smooth sharp tendon hook. This process should be repeated at all wounds for all tendons regardless of whether or not they have already been found to be divided in one wound. Injuries at multiple levels do occur and may be missed, especially if the division is only partial at one of them. It is worthy of re-emphasis that all blood clot

and bloodstaining should be thoroughly pursued and explored for this frequently reveals partial injuries.

## ABRASION AND AVULSION OF TENDONS

Such injuries, especially of the extensors, are not uncommon in industrial and road traffic accidents. Much raw tendon is exposed to which adhesion can occur and the chance of successful function following primary repair is considerably less than it is in tidy lacerations.

Where the extensor tendon has been only partially abraded, the paratenon is lost and the blood supply of the tendon compromised. Gross contamination is the rule rather than the exception. These considerations apart, however, such unpromising material often does surprisingly well, although later tenolysis is very likely to be required. If satisfactory skin cover can be obtained, therefore, the tendon should be thoroughly cleansed, loose ends trimmed away and the tendon retained.

*Tendons which have been avulsed* are often found lying dangling from the wound in crush and roller injuries. However, their substance is often remarkably undamaged and if there is a chance that the part on which they act can be salvaged, they should be cleansed and sutured back in place, either from whence they came or to an adjacent motor better preserved, for they are difficult — and in some instances impossible — to replace.

## MUSCLE

*Muscle bellies* are frequently injured in crush and avulsion injury. Dead muscle is an ideal medium for the growth of anaerobic organisms. At exploration the identification and excision of all non-viable muscle is therefore imperative. This is done using three criteria.

*Appearance.* Due to venous congestion and oedema, the muscle which is probably non-viable bulges from its fascial covering and has a dark plum-red colour contrasting with the brownish red of adjacent normal muscle.

*Twitch.* When normal muscle is grasped gently with toothed dissecting forceps, it twitches. Dead muscle does not. This test is valid regardless of the agents being used by the anaesthetist, but twitch decreases progressively with tourniquet ischaemia.

*Perfusion.* Especially in macroreplantation, it is important to know whether muscle in the amputated part will be perfused after vessel repair. Therefore, perfusion through the major artery is undertaken before replantation with heparinized Ringer's lactate. Any muscle which does not ooze lactate is excised. This practice has markedly increased survival and decreased infection. It is equally applicable in revascularization.

## INDICATIONS

Primary repair of all injured tendons, regardless of the site, offers the best chance of speedy return of good function<sup>469-471</sup>. Contraindications are few. They include:

*Loss of a segment of tendon* — best judged by approximating the ends and assessing the resultant posture.

*Joint injuries* of such severity that they preclude early motion.

*Fractures* which cannot be accurately reduced and securely fixed.

*Skin loss* which requires distant flap coverage.

This is not the place to detail technique and post-operative management, only to stress that meticulous attention to these details is imperative if this philosophy is to prove successful.

*Distal injuries of flexor digitorum profundus*. Tendon advancement was commonly practiced in the past, with limits ranging from 0.75 to 2.5 cm. Attempting to resolve the issue, one cadaveric study determined that 1 cm was the maximum permissible shortening<sup>472</sup>. Any advancement risks the development of a *quadriga syndrome* (p. 174). Rather, direct repair should be undertaken in all cases. Repair of an *avulsion* of the profundus, which is often diagnosed long after injury, can be performed after various delays which depend upon the level at which the tendon has arrested proximally (p. 36). If repair has been left undone for too long, and the joint becomes unstable, fusion of the distal interphalangeal joint is indicated<sup>473</sup>.

Although there is debate on the matter<sup>474</sup>, partial tendon injuries should be repaired to avoid later triggering, entrapment or rupture<sup>475</sup> (Fig. 1.152).



Fig. 1.152 This patient was explored secondarily because of lack of motion in a previously lacerated finger. He was found to have a partial laceration which was locking on the A2 pulley, preventing motion.

Muscle lacerations should be repaired with the expectation that useful, but not normal<sup>476</sup>, function will be regained. Suture of muscle is sufficiently difficult in some instances that tendon grafts should be used to strengthen the repair<sup>477</sup>.

See Green D P 1993 Operative Hand Surgery, 3rd edn. Churchill Livingstone, New York, pp. 1827, 1937.

## Nerve

## LACERATION

Where sensory and motor loss of characteristic distribution has been demonstrated on initial examination, exploration usually reveals a clear division of the nerve. Being softer and rather more adherent to adjacent soft tissue, nerve ends are somewhat less easy to locate than are the firmer tendon ends. The proximal end of the *ulnar nerve* divided at the wrist tends to adhere to the deep, radial surface of flexor carpi ulnaris and during exploration of the wound tends to be retracted with it. Likewise, the proximal end of the *median nerve* divided somewhat higher adheres to the deep surface of flexor digitorum superficialis. The ulnar nerve is further obscured by the more superficial and anterior ulnar artery with which it constitutes a neurovascular bundle invested by adipose tissue. Any difficulty encountered in locating nerve ends should be overcome by applying the rule which is absolute in *secondary* exploration — one must always dissect from normal tissue towards the injury. Thus in seeking out the end of a lacerated structure — and this is especially true in difficult exposures such as the upper forearm or the deep spaces of the hand — the incision should be extended adequately and the nerve, or vessel, displayed in uninjured tissue and traced from there. In applying this maxim to an injured nerve, there is clearly more hazard in dissecting the distal nerve end from distal proximally, for branches will be encountered and must be protected and incorporated in the nerve as the surgeon advances.

Once the ends have been located, correct orientation is essential in mixed nerves if the fullest recovery is to follow nerve suture. This is achieved, using magnifying loupes, by:

1. Matching blood vessels.
2. Drawing a fascicular plan (Fig. 1.153): gripping the epineurium with very fine forceps, the nerve endings are rotated so that they can be examined either through strong loupes or the operating microscope. The fascicular bundles are of different size and, if the microscope is being used, can be seen to consist of a differing number of fascicles. A plan should be drawn of each end in turn, either

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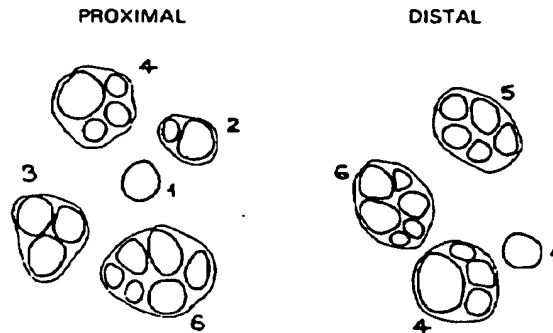


Fig. 1.153 This is a sketch of the fascicular bundles of the proximal and distal ends of a severed median nerve. It will be seen by comparing the size and number of fascicles contained in each bundle that accurate matching can be undertaken.

mentally or using a sterile pen and paper, and then the two ends matched.

3. Knowledge of the normal *internal anatomy* of the peripheral nerves<sup>478-481</sup> will allow one to predict the location of certain nerves, such as the motor branches of ulnar and median. If the similarity in size, shape and fascicular content is not recognized by the techniques in (2) above, this knowledge will help to orient the proximal end. The distal end can be mapped by tracing the relevant motor branch proximally from its actual take-off to the site of injury.
4. *Electrical stimulation* of the proximal stump<sup>482,483</sup> has not gained wide use as it involves a 'wake-up' general anaesthesia technique.
5. *Histochemical identification*<sup>484,485</sup> of motor and sensory fascicles is theoretically of most value where a nerve defect has to be grafted. While logical, there is no clinical evidence as yet that this is beneficial.

#### Indications

Primary or secondary repair of nerves has been the subject of some controversy. The ease of matching in the fresh injury, the impracticability of performing a delayed repair when tendons have been sutured primarily and the increased tension which results from the greater resection of nerve end necessary in secondary repair has made primary epineural suture<sup>486,487</sup>, supplemented where necessary by fascicular aligning sutures, the method of choice for the author. There is also experimental evidence that the results are superior<sup>488</sup> following primary repair. Partial nerve lacerations (Fig. 1.154) must *always* be repaired primarily, for separating intact from divided fascicles secondarily is an inexact science.

\*  
Sutured  
→ suturing penetrates & aligns tissues.



Fig. 1.154 Partial laceration of a median nerve injury. Primary repair is mandatory.

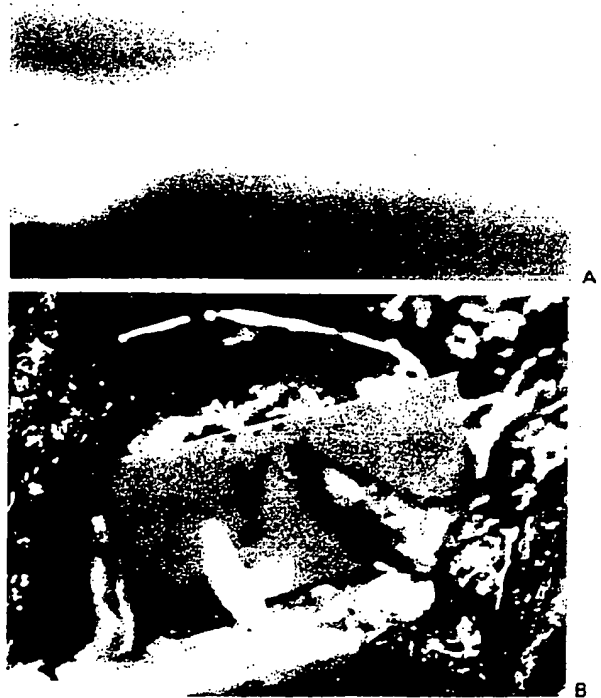


Fig. 1.155 A fracture of the ulna was inflicted on this child when she came between victim and assailant. The exploration revealed an injury of the ulnar nerve due to bone fragment. The nerve damage was sufficiently well localized as to justify primary nerve graft.

Where a defect exists in the nerve primary grafting should be performed only when the surgeon is confident that he is joining good nerve, that the skeleton is well stabilized, that the nerve graft has soft tissue cover

which is well-vascularized and that healing will occur *per primam* (Fig. 1.155).

If *any* doubt exists as to the quality of nerve presenting for repair, it should be left and explored once the wounds are healed. An unsatisfactory suture does the patient a disservice because several months will pass before a decision will be taken to explore a nerve which is recorded as 'repaired' in the initial operation note. When it is elected to wait, there is some merit in attaching the nerve ends one to the other to prevent retraction and thereby shorten the gap.

Considerations of *splintage* following surgery clearly have no place in this text, concerned as it is with diagnosis and indications. However, the reader may perhaps excuse one observation. It is common practice to splint to protect a nerve repair, for example, wrist flexion following median nerve suture. This may be unwise, for scar will form to adjacent tissues which will then place traction on the nerve with wrist extension, and will limit the necessary longitudinal excursion present in all nerves with wrist motion<sup>499</sup>. It may be wiser perhaps to splint against the nerve repair to a degree which peroperative inspection shows that the repair can sustain. With the radial cutaneous nerve, so prone to painful neuroma formation, it is the author's practice to splint in full *ulnar* deviation provided the repair remains secure.

See Green D P 1993 *Operative Hand Surgery*, 3rd edn. Churchill Livingstone, New York, p. 1320.

#### AVULSION

Where a nerve has been avulsed the injury is inflicted at differing levels in different fascicles and traction damage occurs both proximal and distal to the obvious division. This is revealed by several observations:

The ends, both proximal and distal, are much thinner than expected or indeed than is the nerve itself when it is dissected out further away from the wound.

The ends frequently overlap.

When inspected with magnification the nerve can be seen to be the site of multiple sub-epineurial haemorrhages for some distance from its end.

Suture carries a greatly reduced hope of full function, although superior in children compared to adults<sup>500</sup>.

#### INJURIES IN CONTINUITY

When characteristic sensory and motor loss have been found on examination, but, despite exhaustive exploration of all wounds, the nerve in question is found to be intact an *axonotmesis* or *neurapraxia* — Sunderland in-

juries types I and II — (p. 42 and p. 241) has been sustained. In order to facilitate possible secondary neurolysis, the exact site and extent of any bruising or swelling of the nerve should be recorded at exploration. If such swelling is significant, primary epineurotomy may reduce nerve damage and speed recovery.

#### Traction injury

A long section of the nerve is damaged in traction injuries; it is swollen throughout to a varying degree and considerable quantities of extravasated blood may be visible through the epineurium. If this is creating tension, evidenced by induration of the nerve on palpation, then it should be released by incising the epineurium.

#### Compression

Prolonged compression sufficient to produce lasting nerve disturbance is an unusual primary injury but may be found during exploration of an acute carpal tunnel or compartment syndrome. In the latter situation the nerve injury corresponds exactly to the extent of the forearm muscle bellies. The nerve is constricted, pale and avascular.

In all injuries in continuity, the significant point is whether or not the continuity of the axons themselves has been broken. The two possibilities have been given distinct names and the prognosis differs considerably (p. 241):

*Neurapraxia*. Axons intact; prognosis: early, full recovery.

*Axonotmesis*. Axons divided; prognosis: late, possibly incomplete, recovery.

It is not possible to distinguish between the two at the time of primary injury. Nerve conduction studies are of no value in making the distinction until some 48 hours to 8 days after injury, when conduction distal to the site of injury will remain only in the neurapraxia (the time until loss of distal conduction differs in various studies).

#### Vessel

Named arteries in the region of injury should be inspected, both under tourniquet control and after its release. Lacerations in large vessels should be occluded proximally and distally with bulldog clamps and in small vessels with microvascular clamps. In the large vessel it is also prudent to dissect out the next most proximal branch and place a soft sling around the main vessel just above to afford immediate control should a clamp slip. The tourniquet should then be released and the speed of arterial inflow through other vessels to the

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region served by the lacerated one assessed before the choice between vascular repair and ligation is made.

Viability should not be the only criterion of the need to perform a vascular repair as relative ischaemia may produce later disability. Radial or ulnar arteries at the wrist should be repaired if the division is clean and the injury otherwise suitable. Studies have shown that approximately half of the vessels repaired at the wrist will remain patent, that there is no absolute determinant of the need for repair, but that eventual patency will be more likely when the back pressure in the distal cut end is low and the hand is relatively ischaemic<sup>491-494</sup>. Most fingers have a dominant digital artery as evidenced by the calibre of the vessel. The larger vessel is usually on the ulnar border of the thumb, the index and middle fingers and on the radial border of the ring and small. Where only one has been divided it should be repaired if experience is available both to judge that it is of significant calibre and to perform the microvascular repair. When neither carries flow, the finger is likely to be non-viable and vascular reconstruction is essential.

*Partial lacerations* are especially likely to produce considerable blood loss as haemostasis cannot be effected by the usual means of vessel retraction (p. 45).

*Torsion and compression* of vessels may result in marked spasm and this may persist despite removal of the cause. The vessel should be observed until the spasm settles. This may be encouraged by the application of a stream of warm lignocaine 20%<sup>495</sup>, or, as reported from one institution, phosphoenolpyruvate<sup>496</sup>. Where it does not resolve in vessels of consequence, flow should be restored by exploratory arteriotomy and replacement with a reversed vein graft where significant damage to the vessel is found.

Where vascular repair is to be performed, three major factors influence the outcome and these should be assessed during exploration.

1. *Proximal flow.* On release of the tourniquet it is probable that there will be no flow evident, due to vasospasm and a small terminal thrombus. These problems should be overcome by dilatation of the vessel after resection of its cut end. This should result in brisk, pulsatile bleeding of considerable force which does not reduce provided the vessel is held out to length (Fig. 1.156). As a simple guide to desired force, blood from a digital artery should reach the end of the hand table, from the radial or ulnar it should reach the near side of the nurse's table and from the brachial artery the far side!
2. *Uninjured vessel ends.* These should be inspected under magnification appropriate to the vessel size, seeking any evidence of intimal damage or



Fig. 1.156 A. Exploration of this wound revealed a traumatic aneurysm due to a partial laceration in the ulnar artery. B. After application of clamps and controlling slings, resection revealed good proximal flow. C. Direct anastomosis proved possible.

With Sutures

separation, of intramural or intraluminal thrombus or of vessel disease.

3. *Good run-off.* The amputated part of the limb distal to the vascular injury should be examined again for any evidence of injury likely to involve the distal vessel. The vessel distal to the injury should be exposed for a length which varies according to the degree of avulsion thought to be involved in the trauma. That vessel should be inspected for any evidence of damage, and in particular for:
  - (i) thrombus
  - (ii) avulsed branches — the repair should be performed *distal* to the first intact branch encountered
  - (iii) intimal tears, which can be seen through the wall as transverse areas of discoloration and which can be felt as irregularities with micro-forceps moved gently along the vessel lightly gripped.
  - (iv) the 'ribbon sign'<sup>107</sup> — this a series of curls in the course of a vessel normally straight, similar to those which can be produced in ribbons by pulling them firmly through a constriction. It is a sign of irreversible vessel damage.

Any damaged vessel must be resected and replaced by a suitable substitute, usually vein although arterial grafts<sup>108</sup> are superior in the following circumstances (Fig. 1.157):

1. Long defects, commonly encountered in revascularizations
2. Where the defect is between a large-calibre vessel and one or more of small calibre
3. In thumb replantation in which a long bypass from the radial artery improves exposure.

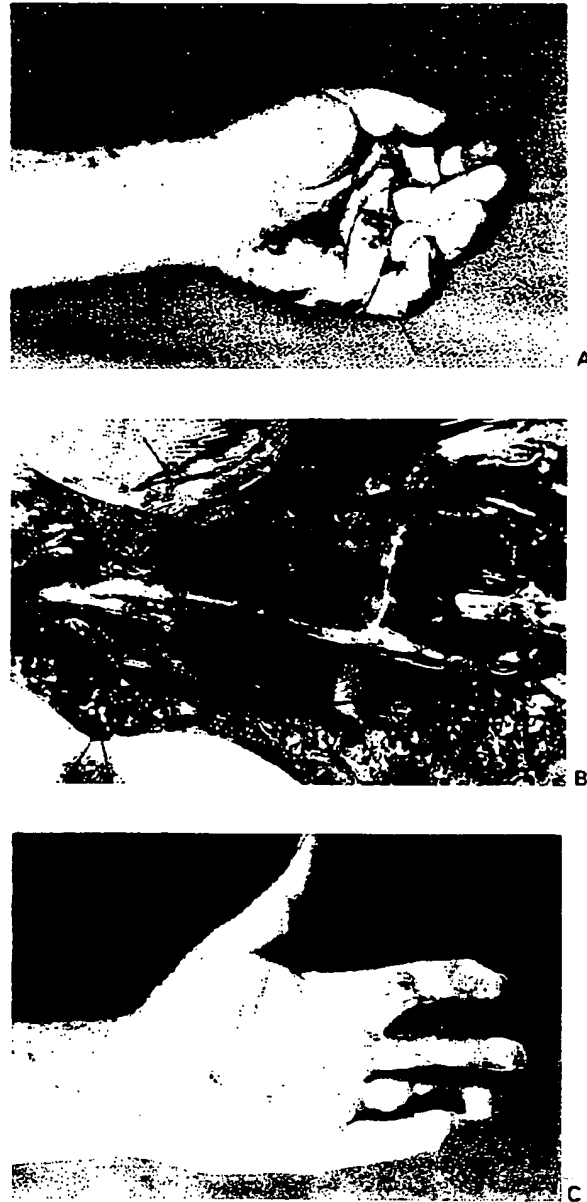
The arterial grafts are obtained from the posterior interosseous artery or the subscapular tree.

#### Skin

The possibility of deep damage underlying apparently innocuous puncture wounds has been emphasised. They must be explored to their full extent using a probe and the presence of blood staining as guides.

#### INJECTION INJURIES

The urgency required in handling similar small wounds due to *high compression injection*<sup>500-502</sup> cannot be stressed too strongly. Such injuries may inject any number of substances — paint<sup>503-506</sup>, grease<sup>507</sup>, hydraulic fluid, molten plastic<sup>508</sup> are only the most common. The distance injected is a function of the pressure in the



**Fig. 1.157** Arterial graft. A. This patient presented with devascularization of the fingers following an untidy, ill-defined crush injury to the hand. Conservative management was undertaken with respect to the debridement and skin cover. B. A graft taken from the subscapular tree was used to revascularize the digits. The subscapular artery was anastomosed to the ulnar artery (left of the field), the circumflex scapular to the deep palmar arch and two branches of the thoracodorsal artery to the common digital arteries to the second and fourth spaces respectively. C. Satisfactory revascularization was achieved.

Stephen Copeland

# Shoulder Surgery



With a foreword by

**Saunders**

# Shoulder Surgery

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mion. Traditionally, the amount of acromion removed has been approximately 7-8 mm in thickness and should extend posteriorly approximately one-quarter to one-third the length of the acromion. Recent work in our laboratory, however, suggests that this may be too much bone and that only 4-5 mm of bone resection is necessary. The emphasis should be on contouring a smooth undersurface of the acromion for contact. The wedge of bone excised should, however, consist of the full width of the acromion from the medial to the lateral border and it is then cut free of the attached soft tissue by sharp dissection. The thickness of the acromion can then be palpated between the index finger and thumb. A double-action laminectomy rongeur, rasp or burr can be used to smooth the undersurface of the remaining acromion and remove any remaining uneven ridges of bone. In most cases, a properly performed acromioplasty removes a portion of the acromial aspect of the acromioclavicular joint, often leaving the undersurface of the distal clavicle quite prominent; these rough edges should then be smoothed with a rasp. This completes the modified acromioclavicular arthroplasty which widens the subacromial space medially. If the entire distal clavicle needs to be removed, this can be performed from underneath with a burr or rongeur. Approaching the acromioclavicular joint from below prevents violation of the superior acromioclavicular ligaments, helping to preserve stability of the joint.

It is important to re-emphasize that lateral or radical acromionectomy should be avoided.<sup>42-44</sup> This procedure deforms the deltoid by removing its site of origin. Without this normal site of attachment, the deltoid is weakened and shoulder function is severely compromised. Transacromial approaches can also weaken the deltoid or result in non-union and are not recommended. In addition, decompression is technically difficult to perform from this approach.

### Rotator cuff repair

Attention is now turned towards mobilizing the torn rotator cuff tissue. The biceps tendon is inspected to see whether it is intact, frayed or

torn. The oblique course of the biceps tendon runs just beneath the rotator interval tissue which is formed by the junction of the supraspinatus and subscapularis tendons. If intact, the biceps is left in its groove and not transposed posteriorly. In rare situations, the intact tendon can be incorporated into the rotator cuff repair to help provide additional tissue coverage. If the biceps tendon is torn, the proximal stump can sometimes be used in the repair and the distal stump is tenodesed in the groove if it has not fully retracted distally into the arm.

The leading edge of the rotator cuff tear is then identified and sutures are placed into the medial aspect of the tear. Zero or no. 1 non-absorbable sutures are used. An elevator is then used to sweep the superficial aspect of the bursa beneath the coracoid in the area of the subscapularis. It is important to remove only the superficial bursa, as the deep bursa may provide blood flow to the edges of the torn rotator cuff. Minimal tissue is debrided from the leading edge of the tear, as it has been shown that this tissue does have blood supply.<sup>45,46</sup>

The cuff is then mobilized from anterior to posterior in a sequential fashion. Multiple stay sutures are placed at the visible edge of the torn tendons. Internal rotation and extension of the free arm help to provide access to the posterior tissues. The posterior aspect of the cuff is also more accessible because of the 'more posteriorly' placed deltoid split. Attention is initially turned towards the bursal surface of the cuff. A periosteal elevator or scissors can be used to mobilize the cuff and its associated bursa from the undersurface of the acromion. It is important to emphasize that the undersurface of the acromion is a common location for cuff and bursal adhesions and this area should be released before the acromioplasty to prevent inadvertent extension of the tear. Generally, though, these adhesions are underneath the posterolateral aspect of the acromion and the deltoid muscle, and become more apparent after the acromioplasty is performed. The stay sutures previously placed are used to advance the torn edge of the rotator cuff anteriorly. To gain additional posterior exposure, the humeral head can be depressed with a blunt retractor while in a

position of internal rotation and extension. After complete bursal surface release and exposure, the posterior tissues are assessed to determine the full extent of the tear. Usually a portion of the infraspinatus and/or the teres minor remain attached to the humeral head. The surgeon should be careful not to remove these during attempts at mobilization and release of surrounding adhesions.

Attention is then turned towards mobilization and release of the undersurface of the rotator cuff. The undersurface is commonly scarred to the glenoid rim and base of the coracoid. Undersurface release is generally carried out bluntly with an elevator. Sharp dissection may be carried out with scissors, but this should be performed with caution. If scissors are used, spreading is more advisable than cutting in the posterior aspect of the cuff, especially near the base of the scapular spine in the vicinity of the suprascapular nerve. After a complete and systematic release of the undersurface of the cuff from posterior to anterior, the excursion of the torn tendons is assessed by pulling

on the stay sutures. To ensure a successful repair, the edges of the torn tendon should reach the anatomical neck of the humerus with the arm in a functional position of 10–15° of forward elevation and 10° of abduction.

There are several manoeuvres which can be performed if sufficient tendon cannot be mobilized to bring the leading edge of the cuff to the anatomical neck. The rotator interval and coracohumeral ligament should be released at the base of the coracoid (Figure 23.4). The coracohumeral ligament is often contracted, thus inhibiting the lateral and distal advancement of the supraspinatus tendon. This complete release of the rotator interval and coracohumeral ligament at the base of the coracoid is termed 'the interval slide', and will allow the supraspinatus to be mobilized up to 1.0–1.5 cm. We have avoided the need to transfer the upper portion of the subscapularis by using this manoeuvre. However, if the subscapularis transfer is performed, it is important not to transfer the underlying capsule as this may lead to instability.



Fig. 23.4 (A) To release scarring of the coracohumeral ligament at the base of the coracoid, an interval release is sharply performed with scissors beginning laterally and incising directly to the coracoid base. (B) The complete release of the rotator interval and coracohumeral ligament is termed the interval slide as the tissues, once incised, are slid along the dotted line, thus mobilizing the retracted tissue in a lateral direction. Sliding the tissues in a lateral direction at the interval allows for 1.0–1.5 cm of new length for repair.

If more mobilization is required, further releases can be performed along the posterior and superior aspect of the cuff on the glenoid rim. Since we have been releasing the rotator interval, however, these manoeuvres have rarely been necessary. When required, capsular release along the glenoid rim should be performed bluntly or cautiously with scissors, spreading more than cutting. Sharp dissection in this area can injure the muscle belly of the infraspinatus and/or the suprascapular nerve and should be avoided. In the majority of cases, these manoeuvres will provide sufficient mobilization to allow the torn rotator cuff tendons to reach the anatomical neck with the shoulder in the desired position. Of note, we have not found the use of synthetic material or allografts to be helpful in our repairs. With mobilization complete, the next step becomes the actual repair of the rotator cuff to bone.

The greater tuberosity is prepared for tendon repair by 'scarifying' the anatomical neck area with a large curette. A deep trough is not used as it increases the amount of tendon mobilization required and has not been found necessary to promote tendon-to-bone healing. Multiple drill holes (four or five) are then placed into the greater tuberosity starting medially in the anatomical neck. Corresponding lateral tuberosity holes are made, leaving a 1.0–1.5 cm bridge of tuberosity bone between the holes and thereby creating a bony tunnel for suture repair to bone. Zero or no braided nylon sutures are then passed through the tunnels with a curved needle. Although suture anchors can be used in the greater tuberosity, the bone may be osteoporotic allowing for potential pull-out of the anchors.

During the repair, the arm is held in approximately 10–15° of flexion and 10° of abduction and the sutures are tied over the bony bridges. This allows excellent apposition of the bone and rotator cuff edge. If an interval slide has been performed, the rotator interval should be closed in such a way as to realign the mobilized supraspinatus edge further laterally than the corresponding subscapularis edge of the interval. If there is a split between the infraspinatus and teres minor (generally the 'apex' of the tear), this should also be closed. The side-to-side 'apex stitch' should be

sutured before reapproximation of the distal edges of the tear to allow proper restoration of the intratendinous relationships of the posterior cuff.

If there is a large or massive cuff tear with deficiency of the superomedial aspect of the coracoacromial arch, the preserved coracoacromial ligament is now reattached medially. As mentioned, this provides a superomedial buttress which may provide restraint from superior migration of the humeral head. The deltoid is then meticulously repaired to the cuff of strong deltoid origin which was preserved, and the stay suture in the distal deltoid split is removed. If the cuff of the deltoid origin tissue is of poor quality, drill holes are placed in the acromion and the deltoid is repaired directly to bone. A few subcutaneous absorbable sutures are placed followed by a subcuticular skin closure with an absorbable suture. The arm is immobilized in a sling and swathe for approximately 24 h. We do not use abduction braces, as we feel this tends to put the arm in too much extension, increasing tension across the repair. The swathe is removed at 24 h and precise range of motion exercises are initiated.

### Rehabilitation

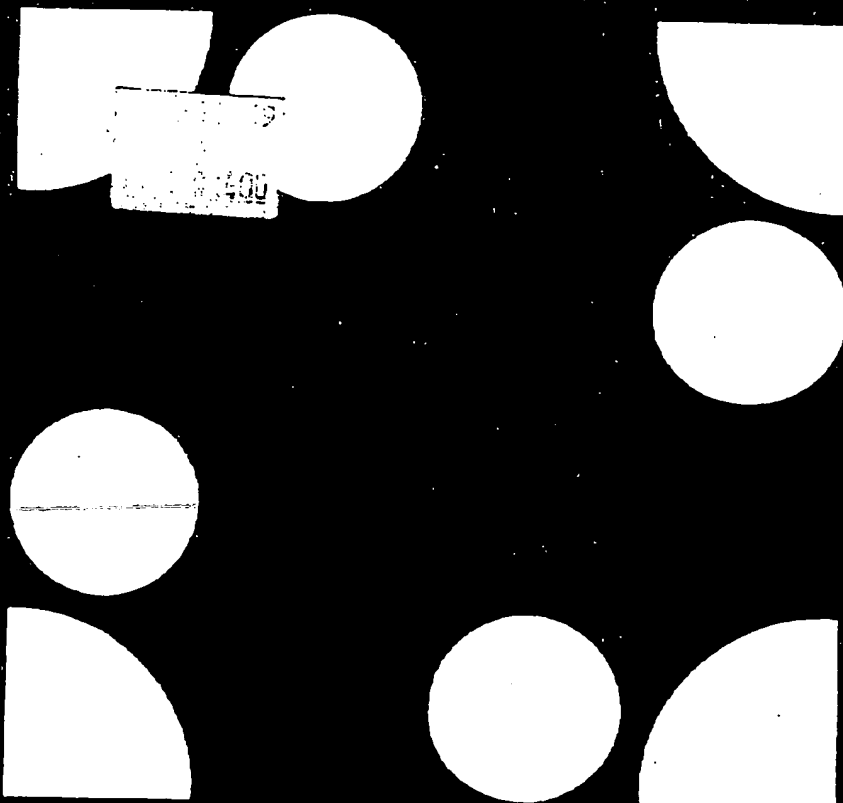
In large and massive tears, the normal Neer Phase I Rehabilitation Program<sup>38</sup> is altered. In the first 6 weeks, only three exercises are performed. These include pendulum exercises, supine external rotation using a stick to 30°, and assisted passive forward elevation to 140°. We like to avoid extension and pulley exercises in the first 4–6 weeks, as this puts stress across the rotator cuff repair. Isometric and active assisted exercises are usually started at the 6–8-week period. These generally begin with active supine external rotation, theraband exercises and active supine forward elevation. Once these exercises are performed, erect forward elevation with the help of a stick is started. This is performed initially with a stick alone, then followed with weights of 1–5 lbs. A hand weight can then be used in the supine position to raise the arm. Weights can be increased to 3 lbs but should not increase past this weight to avoid placing undue stress on the cuff repair. Once these exercises can be performed

one  
repair

\*needle

# ***Current Surgical Diagnosis & Treatment***

Edited by Lawrence W. Way



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Seventh Edition

Edited By

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has been suggested. One contributing mechanism is the hypovolemia and wound hypoxia that generally follow dialysis procedures.

### Diabetes Mellitus

Healing in normally perfused tissue proceeds in the usual manner in well-controlled diabetics. However, both poor healing and infection are serious risks if good control is not maintained. Excessive hyperglycemia in the first week after wounding is particularly damaging, and control of blood sugar should be fairly precise during that time. Hypoglycemia is also a hazard. Therefore, patients with severe diabetes are best managed with insulin and glucose infusions for the first few days (see Chapter 5). Obviously, peripheral ischemia due to diabetes impairs healing. Obesity-related diabetes seems to interfere with repair independently of insulin therapy.

### Oxygen, Anemia, & Perfusion

Wounds in ischemic tissue heal poorly and often not at all. Any decrease in oxygen supply to the wound impairs collagen deposition, angiogenesis, and epithelialization, and increased oxygen delivery can accelerate healing to faster than normal rates. Increased inspired oxygen ( $FI_{O_2}$ ) appears to increase the take of skin grafts. Oxygen supply may be compromised even in the absence of vascular disease by hypovolemia, vasoconstriction, or even sutures that have been tied too tightly.

One might expect that anemia would also exaggerate hypoxia in wounds. In fact, this is not usually true. Hypovolemic anemia affects repair, but normovolemic anemia does not as long as the hematocrit stays above about 15%. The  $PO_2$  of arterial blood rather than the oxygen content of blood reaching the wound is its principal determinant of oxygen supply, since oxygen tensions and collagen synthesis are normal in wounds in anemic but normovolemic animals. Furthermore, increasing arterial  $PO_2$  above the hemoglobin-oxygen dissociation curve enhances collagen synthesis far beyond the effect to be expected on the basis of increased oxygen volume delivered. These statements may be inapplicable if normal compensatory mechanisms such as response to 2,3-bisphosphoglycerate (diphosphoglycerate, DPG) or increased cardiac output are impaired.

Tissue perfusion is the final common denominator of wound nutrition and oxygenation. Probably the single most common cause of wound failure is ischemia and hypoxia due to excessive tension on sutures, causing regional hypoperfusion. Poor wound perfusion is not easily detected. Studies of oxygen tension in human wounds show that many patients (especially after major trauma or surgery) are not optimally perfused. The problem can usually be corrected by increasing fluid infusions.

### Corticosteroids

Exogenous anti-inflammatory corticosteroids impair healing, especially when started in the first 3

days after injury. If they are started after 3 days, the effect is much reduced. They reduce the inflammatory reaction and impair subsequent collagen synthesis. Corticosteroids impair contraction of open wounds no matter when they are given. Their effect on collagen synthesis and inflammation does not readily explain the effect on contraction. There is some evidence that colon repair is not seriously affected by corticosteroids.

Vitamin A can restore corticosteroid-retarded healing toward normal. The effect is clinically useful. It occurs with both systemic and local application of vitamin A. Systemic use of vitamin A for patients who are receiving corticosteroids for control of inflammatory disease must be undertaken cautiously, since the vitamin can counteract the effects of the corticosteroid on the wound, it presumably may counteract other anti-inflammatory effects.

## DECUBITUS ULCERS

Decubitus ulcers are disastrous complications of immobilization. They result from prolonged pressure that robs tissue of its blood supply. Irritative or contaminated injections and prolonged contact with moisture, urine, and feces also play a prominent role. Most patients who contract decubitus ulcers are also poorly nourished. Pressure ulcers are common in drug addicts who take overdoses and lie immobile for many hours. The ulcers vary in depth and often extend from skin to a bony pressure point such as the greater trochanter or the sacrum.

Most decubitus ulcers are preventable. Hospital-acquired ulcers are nearly always the result of inadequate nursing care.

Treatment is difficult and usually prolonged. The first important step is to incise and drain any infected spaces or necrotic tissue. Dead tissue is then debrided until the exposed surfaces are viable and granulating. Many will then heal spontaneously. However, deep ulcers may require surgical closure, sometimes with removal of underlying bone. The defect may require closure by judicious movement of thick, well-vascularized tissue into the affected area. Musculocutaneous flaps are the treatment of choice when chronic infection and significant tissue loss are combined.

## SURGICAL TECHNIQUE

Good surgical technique is the most important means of achieving optimal healing. Most cases of healing failure are due to technical errors. Tissue should be protected from drying and internal or external contamination. The surgeon should use fine instruments; should perform clean, sharp dissection; and should make minimal, skillful use of electrocautery, ligatures, and sutures. All these precautions contribute to the most important goal of surgical technique—

gentle handling of tissue. Even the best ligature or suture is a foreign body that may strangulate tissue if tied tightly. The skillful operator who uses sutures minimally and gently will be rewarded with the best results. Good hemostasis is a laudable objective, but excessive sponging, electrocautery, and tying of small vessels are traumatic and invite infection.

### Wound Closure

As with many other surgical techniques, the exact method of wound closure may be less important than how well it is performed. The tearing strength of sutures from fascia is no greater than 3-4 kg. There is little reason for use of sutures of greater strength than this. Excessively tight closure strangulates tissue and leads to hernia formation and infection.

If surgeons could foresee the future, dehiscence (undesired spontaneous separation of wound edges) would not occur, since techniques to prevent it are well known. The surgeon can choose the techniques to meet the needs and risks of the individual wound (Figs 8-8 to 8-10). The most common technical causes of dehiscence are infection and excessively tight sutures.

The ideal closure for small wounds in healthy patients is with fine interrupted sutures placed loosely and conveniently close to the wound edge. In abdominal wounds, the peritoneum need not be sutured, but posterior and anterior fasciae are sutured with nonabsorbable or slowly absorbable sutures.

Unfortunately, surgeons often must operate on

patients who have impaired wound healing. In these cases, closures must be stronger to avoid dehiscence. A more secure closure begins with a running or mattress absorbable suture in the posterior sheath, joint capsule, or submucosa. The closure is continued with simple or vertical mattress buried retention sutures through the fascia in which the farthest point of penetration is at least 1 cm from the wound edge.

When the tension is placed this far back, the fascial fibers that become weakened by postinjury collagen lysis are not expected to provide critical support. The lytic effect extends for about 5 mm to each side of the wound edge. Subcutaneous layers can be approximated by a few subcuticular sutures. The skin is preferably closed with adhesive strips unless bleeding from the wound or an uneven surface makes adherence of the strips precarious, in which case staples are the next choice. With this fascial closure, the skin can easily be left open for delayed primary or secondary closure. Subcutaneous tissues rarely need to be sutured closed.

Another very secure closure used in difficult abdominal wounds consists of through-and-through mattress sutures of No. 22-26 steel wire placed through all layers, including skin and peritoneum. They are placed about 2.5 cm from the wound edge and 2.5 cm apart. With these sutures pulled together to approximate the wound edges, the fascia can be closed with a running synthetic absorbable suture. The heavy retention sutures are twisted together at the side of the wound to coapt the wound edges. Wound edema will make these

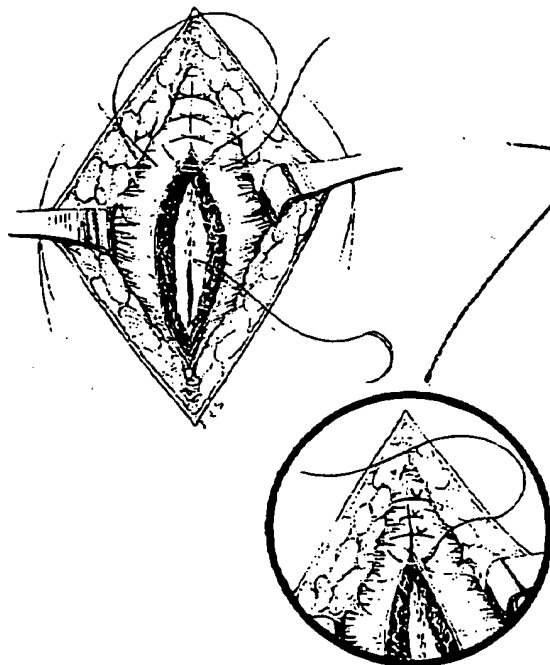


Figure 8-8. Closure of peritoneum with continuous sutures. Fascia closure with figure-of-eight sutures (top) and simple interrupted sutures (bottom) is illustrated.

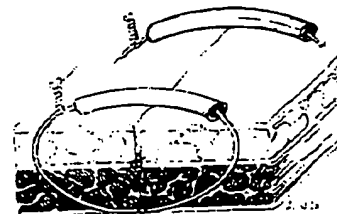
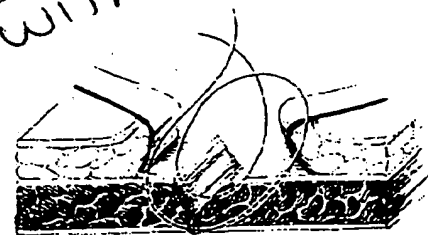
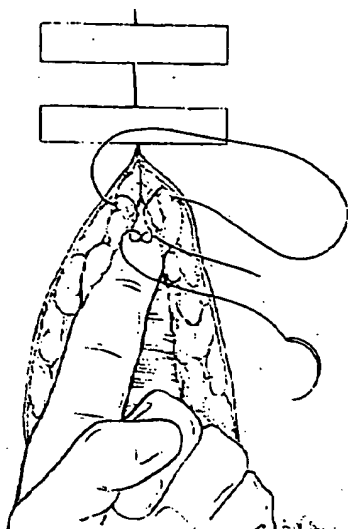


Figure 8-9. Types of retention sutures. Figure-of-eight suture is illustrated above and through-and-through retention sutures below.



\* Figure 8-10. Skin closure with interrupted subdermal sutures and Steri-Strips.

sutures too tight within the next few days, and the twisted wires can be partly untwisted to prevent strangulation of tissue and cutting through of sutures. Plastic sutures are not recommended for this closure, since they cannot be twisted to tighten or loosen as required. Sutures strung across the open wound edge act as bowstrings and can cut through bowel, resulting in fistula formation. This through-and-through retention-closure with very strong wire is painful and should be used only when necessary. It is the best method for secondary closure of a wound dehiscence.

In all closures, sutures should be placed as far apart as possible consistent with approximation of tissue. Sutures placed too tightly and too close together obstruct blood supply to the wound. In most cases of dehiscence, suture material cuts through tissue and is not broken or untied.

It is useful to assess wound risk in advance, so that the proper choice of closure can be made easily (Table 8-1).

Delayed primary closure is a technique by which the wound is held open for 4-5 days and then closed with skin tapes. The environs of the wound are inspected daily to be sure that invasive infection is absent, but if there is no need to disturb the dressing, it is left in place until the fourth or fifth day, when, under sterile conditions, the dressing is removed and the wound is closed. During the delay period, angiogenesis and healing start, and bacteria are cleared from the wound. The success of this method depends on the ability of the surgeon to detect minor signs of infection. Merely leaving the wound open for 4 days does not guarantee that it will not become infected, and

some wounds (eg, fibrin-covered or inflamed wounds) should not be closed even on the fourth, fifth, or sixth day. Ninety percent of wounds managed by delayed primary closure should heal without infection.

## POSTOPERATIVE CARE

The appearance of delayed wound infection—weeks to years after operation—emphasizes the well-known fact that all wounds are contaminated and that the line between apparent infection and apparent normal repair is a fine one. A minor setback such as a period of cardiac failure or of malnutrition will often allow infection to become established. Most frequently, however, poor tissue perfusion and oxygenation of the wound during the postoperative period are the causes of weakened host resistance. Maintenance of perfusion is the essence of postoperative care; however, there are few ways of measuring perfusion of subcutaneous tissue and fascia. Urine output, central venous pressure, wedge pressures, etc. are all poor indices. Better indicators are the speed of capillary return (normal: < 1.5 seconds on the forehead or 5 seconds on the knee), thirst, and postural changes in vital signs. New means of measuring perfusion (eg, subcutaneous or transcutaneous oximetry and post-capillary  $PO_2$  determinations) are now being used to assure good perfusion, and they are relevant to wound management. Proper fluid balance and nutritional status should be maintained to ensure the kind of perfusion that will support repair and resist infection.

Postoperative care of the wound also involves cleanliness, protection from trauma, and maximal support of the patient. Even closed wounds can be infected by surface contamination of bacteria, particularly within the first 2-3 days. Bacteria gain entrance most easily through suture tracts. If a wound is likely to be traumatized or contaminated, it should be protected during this time. Such protection may require special dressings such as occlusive sprays or repeated cleansings as well as dressings.

Some mechanical stress enhances healing. Even fracture callus formation is greater if slight motion is allowed. Patients should move and stress their wounds a little. Early ambulation and return to normal activity are, in general, good for repair.

The ideal care of the wound begins in the preoperative period and ends only months later. The patient must be prepared so that optimal conditions exist when the wound is made. Surgical technique must be clean, gentle, and skillful, and the surgeon and staff must be thoughtful and ingenious in protecting the postoperative wound. Postoperatively, wound care includes maintenance of nutrition, blood volume, and oxygenation. Although wound healing is in many ways a local phenomenon, ideal care of the wound is essentially ideal care of the patient.

\* N.B. Sutureing & not tying important in tissue approximation \*

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# THE HAND

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## 16 THE HAND

repair the wound in the emergency room, the reader is referred to subsequent sections which discuss specific injuries. When the exploration and/or repair is completed the skin closure should always be done with care to evert the skin edges and avoid a delay in wound healing (Figs. 5A-5C). Four or five zero, monofilament nylon suture material with a fine atraumatic needle should be used. For small children it is permissible to use absorbable sutures to prevent the later trauma of suture removal.

At times it may be best to delay definitive repair of deep structures. This is particularly true if there has been severe contamination or if the appropriate consultant is not available. If the wound is sharp and clean, it should be closed and dressed. If contaminated it should be left open and suitably dressed and antibiotics started. Even if the consultant cannot immediately see the patient, a phone consultation may be most useful.

Suturing  
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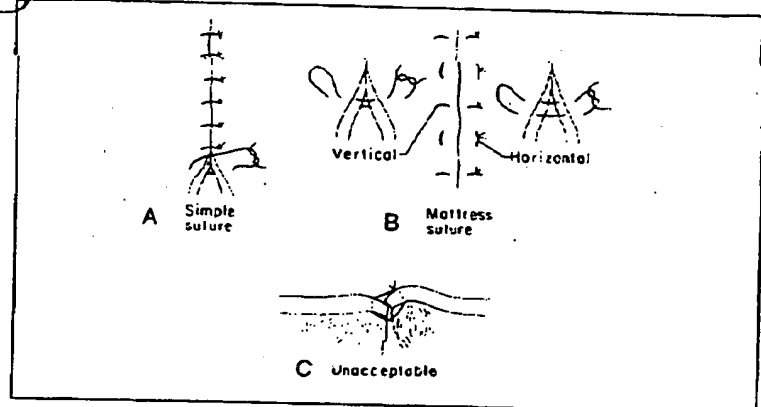


Figure 5

(A) Simple suture (B) Mattress suture (C) Inverting (unacceptable suture)

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with other potentially infected wounds, antibiotics should be given early.

Definitive surgical treatment is recommended for bites that are accompanied by ecchymosis. Incision of the skin with excision of all hemorrhagic tissues with a 5-mm margin is advisable. Vital structures such as tendons, nerves, and vessels should be preserved. The wound can be closed if all tissues appear well vascularized, but if there is any question of viability, the wound is left open. After 4 or 5 days, the wound is inspected under anesthesia and closed by delayed primary suturing or skin grafting.

*stying*

## EXTENSOR TENDON INJURIES

Due to their superficial location, extensor tendons may be injured either by lacerations on the dorsum of the hand and fingers or by closed trauma to the fingers. The nature of the disability depends on the level of the injury.

The most distal injury is at the DIP joint and is called a mallet deformity. It may be due to fracture (see Ch. 5), to tendon disruption from its insertion, or to laceration. Mallet fingers due to tendon disruption are best treated by splinting the joint in full extension (but not hyperextension) for 8 weeks (Fig. 41) while leaving the PIP joint free. Use a padded aluminum splint (commercially available) or a tongue blade cut to the proper length and lined by 5-mm thick foam padding (Reston). Although the splint may be placed either on the dorsal or palmar surface of the digit, it is generally more comfortable and more effective on the dorsum.

If the distal tendon is lacerated and both ends can be identified, they should be repaired. The surgery may be done under digital block anesthesia (see Ch. 2) and is greatly facilitated by wound extension. The repair may be

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done with a variety of fine suture materials, but 5-0 nylon is recommended. Silk should not be used as it is too reactive. A horizontal mattress suture (Fig. 42) is very useful in this situation. An internal splint in the form of a fine K-wire (0.028 or 0.035 inches) passed across the fully extended DIP joint is better than an external splint on a fresh wound. This is an adjunct to an external splint and does not replace it. It is recommended that this be left in place for 8 weeks. After removal of the wire, an external splint is continued at night for approximately another 4 weeks.

Ø with ties

Either a closed or open injury over the PIP joint may result in a boutonnière deformity (see *The Hand: Examination and Diagnosis*, 3rd. Ed.). In the pathophysiology of this lesion, the central extensor mechanism is lacerated or ruptured and the lateral bands, which normally lie dorsal to the axis of rotation and therefore extend the joint, fall volar to this axis and become paradoxical flexors of the PIP joint. This causes the extensor mechanism to shorten and thus hyperextend the distal joint. The early diagnosis of this problem can be somewhat elusive in the closed situation unless the possibility of a boutonnière deformity is considered. Typically the patient presents with the history of having "jammed" the finger, and the area of the joint is swollen. Because of the swelling the diagnosis may not be apparent at once. If the diagnosis is suspected, splint the PIP joint in full extension (Fig. 43) leaving DIP and MCP joints free. If, as the swelling recedes, the patient proves not to have disrupted the extensor mechanism, little has been lost. But if the diagnosis is correct, a very complex and difficult to repair lesion has been avoided. Closed boutonnière injuries will usually respond successfully to closed treatment provided it is instituted early.

## 128 THE HAND

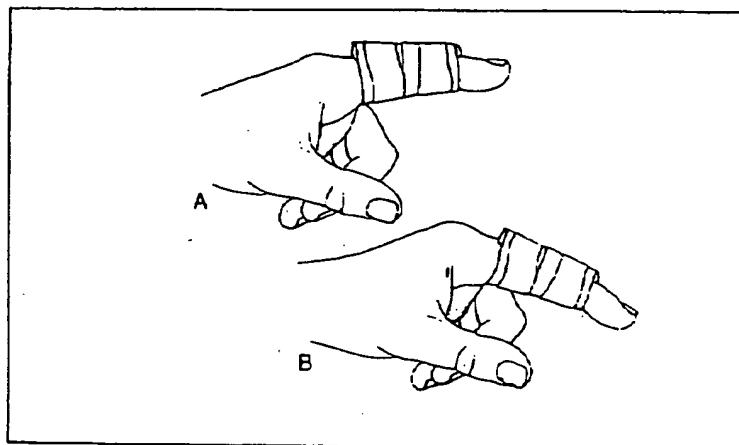


Figure 43 (A&B)  
A boutonniere splint

Open injuries causing a boutonniere deformity are easier to diagnose because one can look in the wound and see the tendon ends. The repair technique is a horizontal mattress suture using 4-0 or 5-0 nylon (Fig. 42). The postoperative fixation is with the same type of splint as used for the closed injury. It may be supplemented by a K-wire transfixing the joint to facilitate wound care. In either case the repair should be splinted for about 6 weeks.

Lacerations to the extensor aponeurosis between the MCP and PIP and PIP and DIP joints are usually not complete. At the time of exposure and repair the surgeon can gauge the amount of stress placed on them by flexing MCP, PIP, and DIP joints and judging which of these joints need to be immobilized. In some cases a forearm-hand-digit splint in the intrinsic plus position (see Ch. 3) will

## USUALLY LESS SEVERE INJURIES 129

be necessary, and in others a digit splint will suffice. In these lacerations a running suture of nylon is very useful. However, if there is no tendon separation on active or passive motion, a splint alone may suffice.

In the digits, retraction of the tendons is not much of a problem, and the ends can be recovered by minimal wound extension. As one moves onto the dorsum of the hand, retraction becomes more of a problem, and recovering the proximal stump, even at the distal metacarpal level, can be quite taxing. If the ends can be found easily, suture material and techniques already described above ~~are satisfactory.~~ If the proximal end cannot be readily found, the wisest course is to close the wound and make arrangements for repair under high regional or general anesthesia in an operating room. Following repair of tendons at hand and wrist level a forearm-hand-digit splint is required. In general the intrinsic plus position previously described is used with perhaps only 30° of MCP flexion. The splint should be utilized for about 3 weeks.

126 THE HAND

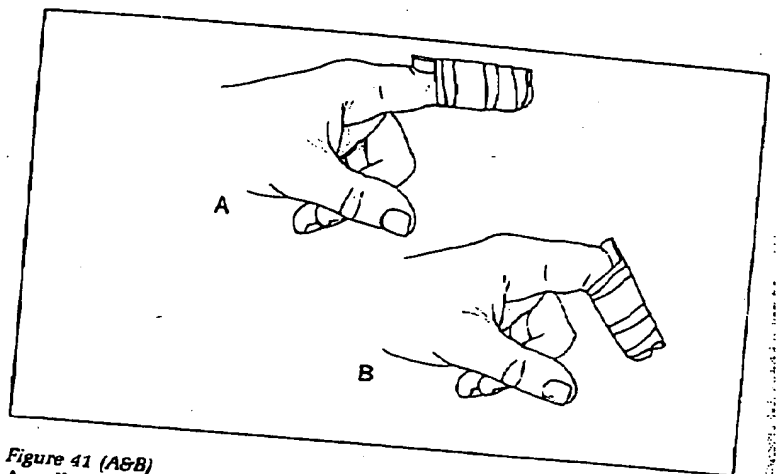


Figure 41 (A&B)  
A mallet finger splint

suturing  
approximates  
& repairs

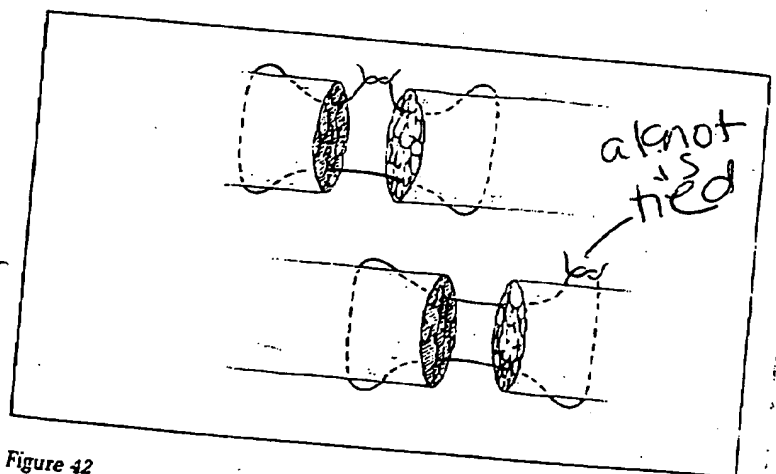


Figure 42  
Technique of a horizontal mattress suture

A  
Little,  
Brown



Spiral<sup>®</sup>  
Manual



# Manual of Surgical Therapeutics

Sixth Edition

Departments of Surgery  
The Medical College of Wisconsin  
and University of Illinois

Edited by Robert E. Condon, M.D.,  
and Lloyd M. Nyhus, M.D.



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Sixth Edition

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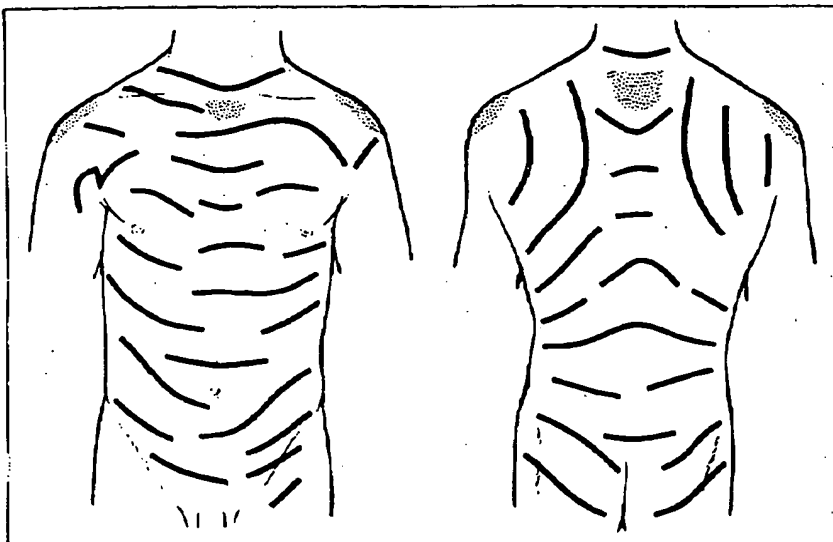
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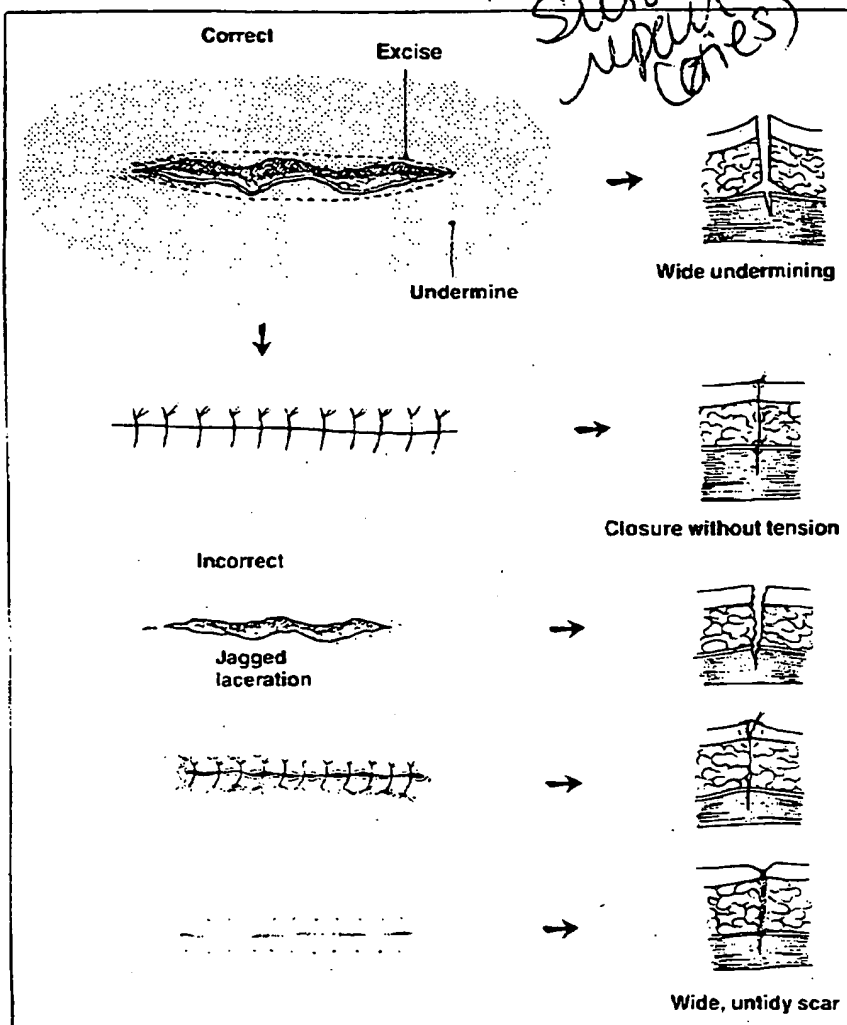
SEA!

# 24

Minor Surgical  
Techniques ✕  
Robert E. Condon



**Fig. 24-1. Placement of elective skin incisions.** When making an elective incision for the removal of a skin or a subcutaneous lesion, a better cosmetic result is obtained if the incision is placed in the lines of skin tension. The shoulder cape, just below the suprasternal notch, and the upper back just below the neck, as indicated by the areas of shading, are zones in which widening of the scar is likely to occur due to motion and tension in multiple directions.



**Fig. 24-2. Suture of scalp and skin lacerations.** *Never shave eyebrows or the scalp; it is usually not necessary to shave around any laceration. Smear sterile lubricating jelly on the hair to hold it away from the wound. Wear cap, mask, and gloves. Gently wash the skin surrounding the laceration with chlorhexidine or iodophor solution. Use sterile towels to set up a sterile field. Establish anesthesia by infiltration of the wound margins, or use a field block. Clean the wound, remove foreign matter, excise irregular wound margins, and debride all nonviable tissue. Undermine all but superficial lacerations to reduce tension. Undermine on the trunk and extremities in the plane between subcutaneous fat and superficial fascia; in the scalp, undermine in the plane just external to the galea; in the face, undermine in the midst of subcutaneous fat. Suture each layer of the wound with fine sutures. Remove skin sutures as soon as possible.*

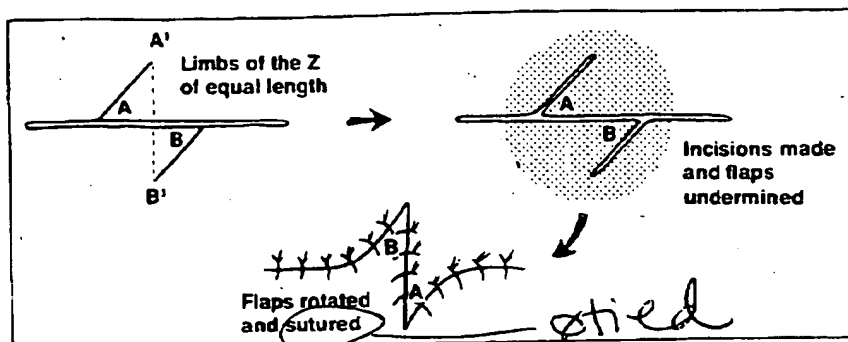


Fig. 24-3. Technique of a Z-plasty. If there is tension along the length of a clean laceration or if the wound crosses a flexion crease, a Z-plasty may be a helpful maneuver to relieve tension.

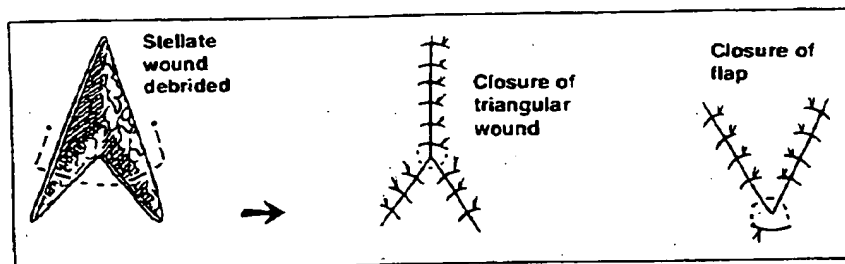


Fig. 24-4. Suturing flaps and tips. Necrosis of the tip of a flap is avoided by use of the "tip stitch," a modified mattress suture that is brought subcutaneously away from the tip so that pressure is not exerted on the tip when the suture is tied.

\*  
undermined  
through  
skin

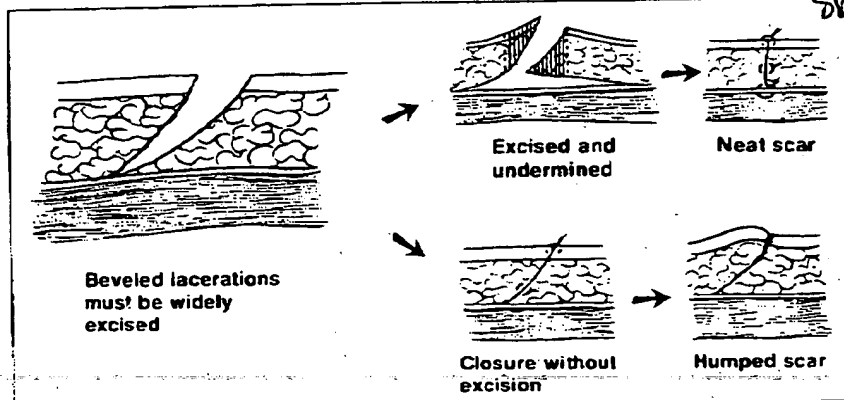


Fig. 24-5. Closure of a beveled laceration. To avert a hump of tissue resulting from contraction of scar, excise a beveled wound to create vertical wound margins and undermine it widely before closure. If the laceration is very deep, excise it in steps at each major layer of the wound.

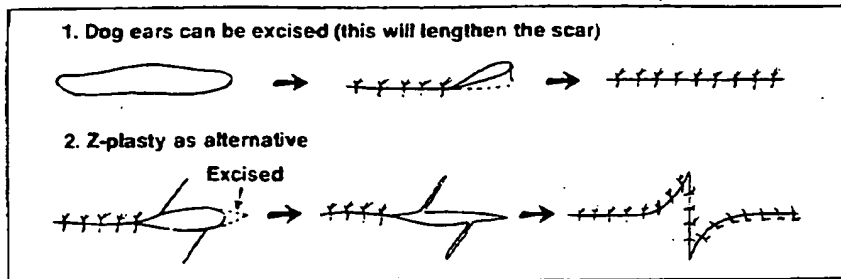


Fig. 24-6. Closure of round and ovoid wounds. Direct suture closure of an ovoid wound sometimes results in a "dog ear." Excision of the dog ear will make the wound longer. Alternatively, a Z-plasty can be used to manage the dog ear; this technique makes the wound area wider.

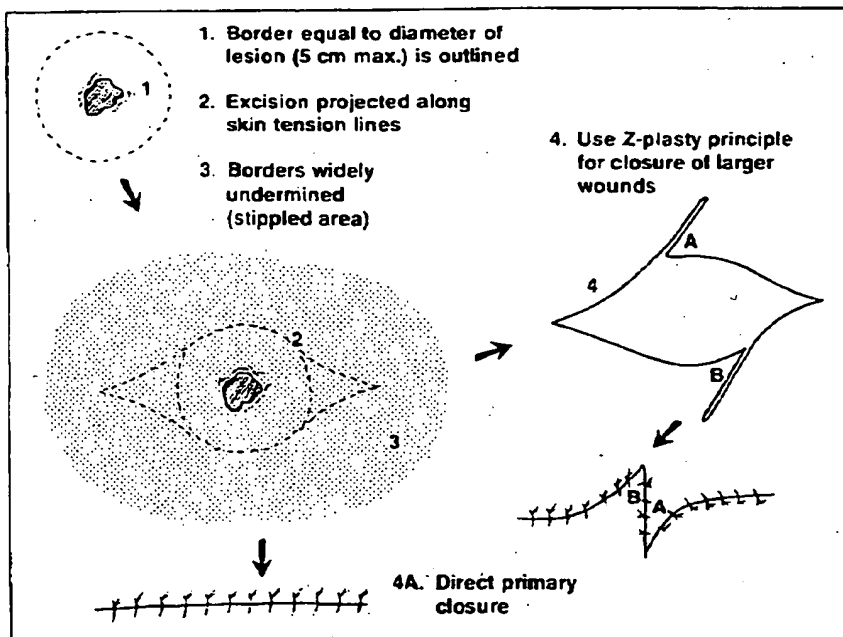
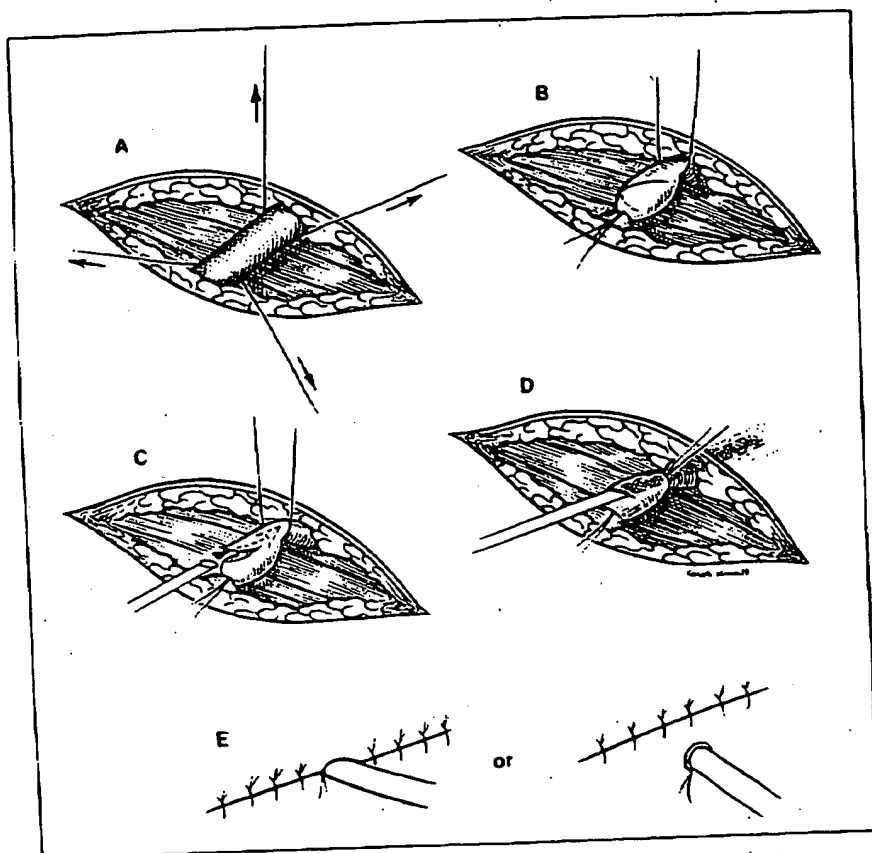
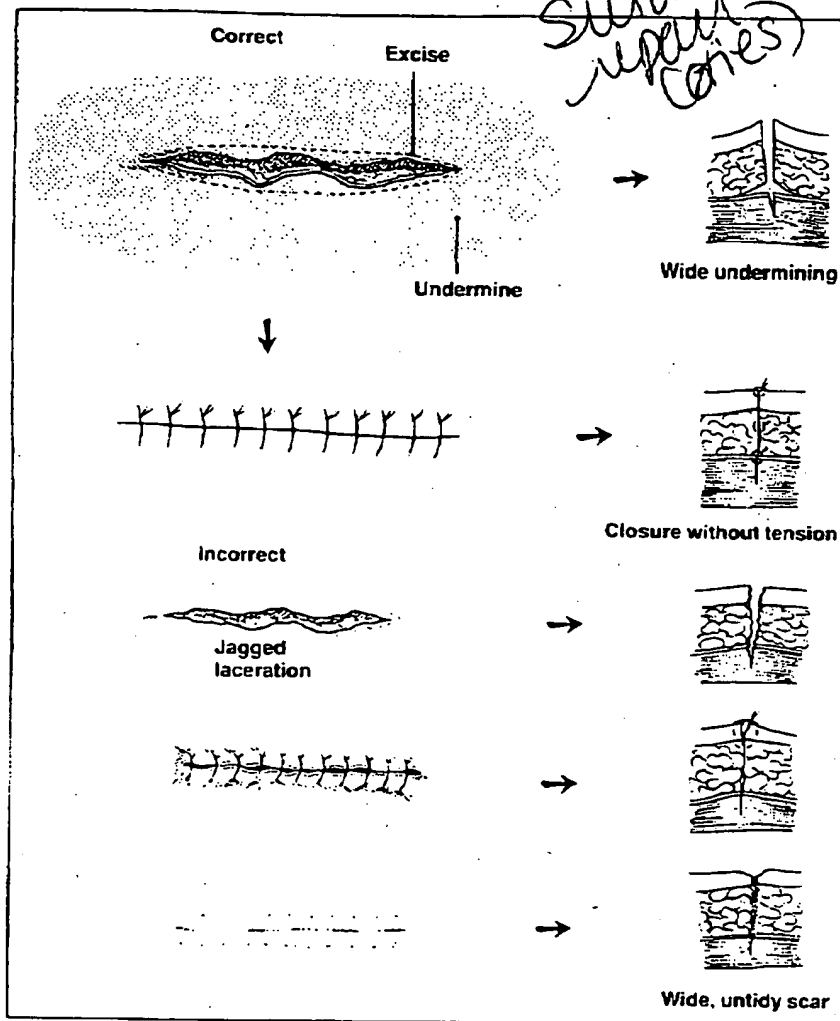


Fig. 24-7. Excision of a suspected malignant skin tumor. Benign skin lesions can be excised with little or no margin. Lesions suspected of being malignant should be excised with a margin equal to the diameter of the tumor, up to a maximum margin of 5 cm. Prolongation of a circular wound by excision of small triangles at either end, together with wide undermining, often permits primary closure. Alternatively, use a Z-plasty.



**Fig. 24-8. Venous cutdown.** In infants, the great saphenous vein just anterior to the medial malleolus and the external jugular vein in the neck are the preferred sites for a cutdown. In adults, the antecubital vein at the elbow or the cephalic vein in the upper arm is preferred, although any accessible vein may be used. Apply a tourniquet proximal to the cutdown site. Prepare a sterile field; incise the skin transversely, dissect out the vein, and pass two ligatures around it (A). Tie the distal ligature (B), and place it on gentle traction. Make a beveled transverse incision halfway through the vein (C); release the tourniquet. Insert the venous catheter; tie the proximal ligature around the vein and catheter (D). Suture the wound, tying the catheter in place (E), and apply a dressing.

tie,  
attach or  
fasten



**Fig. 24-2. Suture of scalp and skin lacerations.** *Never shave eyebrows or the scalp:* it is usually not necessary to shave around any laceration. Smear sterile lubricating jelly on the hair to hold it away from the wound. Wear cap, mask, and gloves. Gently wash the skin surrounding the laceration with chlorhexidine or iodophor solution. Use sterile towels to set up a sterile field. Establish anesthesia by infiltration of the wound margins, or use a field block. Clean the wound, remove foreign matter, excise irregular wound margins, and debride all nonviable tissue. Undermine all but superficial lacerations to reduce tension. Undermine on the trunk and extremities in the plane between subcutaneous fat and superficial fascia; in the scalp, undermine in the plane just external to the galea; in the face, undermine in the midst of subcutaneous fat. Suture each layer of the wound with fine sutures. Remove skin sutures as soon as possible.

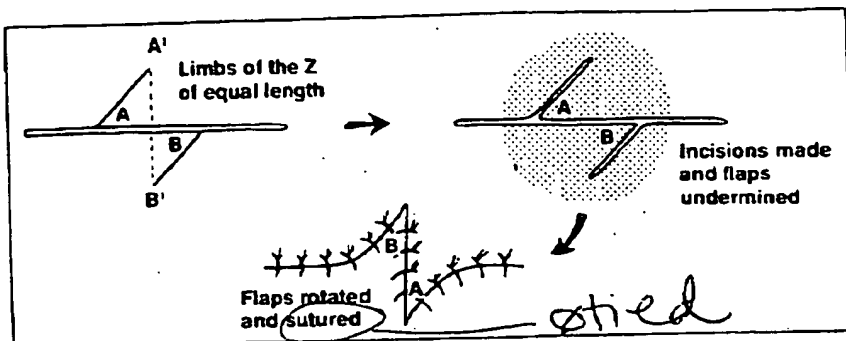


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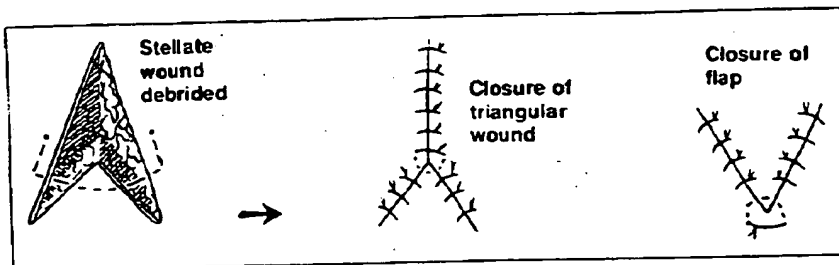


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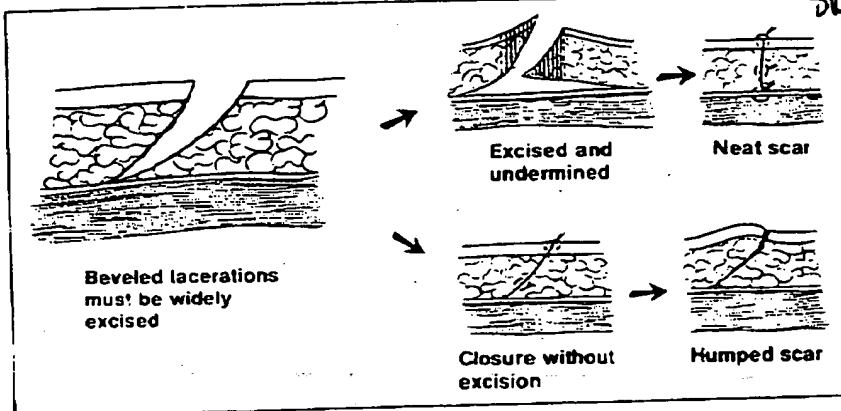
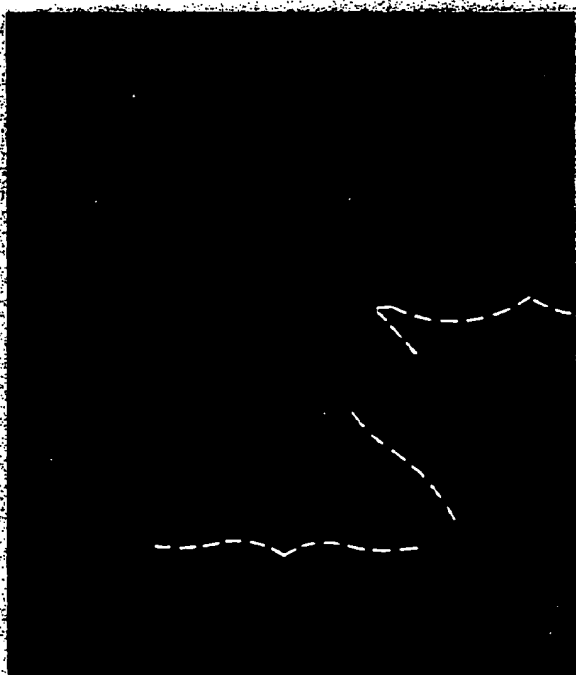


Fig. 24-5. Closure of a beveled laceration. To avert a hump of tissue resulting from contraction of scar, excise a beveled wound to create vertical wound margins and undermine it widely before closure. If the laceration is very deep, excise it in steps at each major layer of the wound.



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**Atlas of  
Aesthetic  
Plastic  
Surgery**

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## LAYER REPAIR OF WOUNDS

Figure 1-4\*

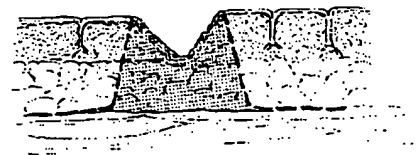
- a. In scar resection the incision should be made to go peripherally as it goes deeper, so that the layer repair will actually evert the skin edges and give extra support to the skin surface. As tissues heal and soften with the passage of time, the scar flattens with minimal spreading, though it is everted and raised at the time of repair.
- b. Whether traumatic, for surgical exposure of underlying tissues or for resection of superficial lesions, a wound should be repaired in layers for the best aesthetic result. Support of the underlying tissues avoids a depressed scar or an adherent scar and gives support to the skin surface itself, thereby helping to avoid the wide, hypertrophic or depressed scar. It also lessens the need for prolonged external support by skin sutures. Buried sutures are placed in such a way that the knots are tied deeply in each layer of repair.
- c. The most superficial of the buried sutures in the layer repair is shown with the knot tied deeply to avoid lumps or bumps in the scar. Repair of the deeper layer should be carried out in a similar fashion. The final skin repair may be by butterfly or strip support, by interrupted or running skin sutures which are removed early, or by an intracuticular running suture which may be left in place for prolonged support.

\* Fig. 1-4 reproduced by permission from J. R. Lewis, Jr. *The Surgery of Scars*. 1964, Blakiston Div., McGraw-Hill Book Co., New York.

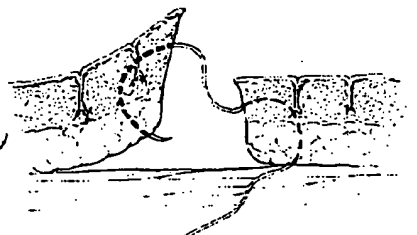
rough skin  
Sutures penetrate tissue with a needle

Driles

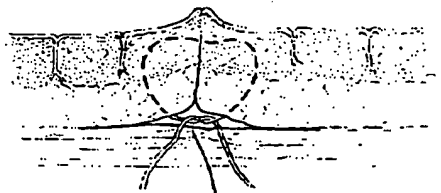
Suturing



a



b



1-4

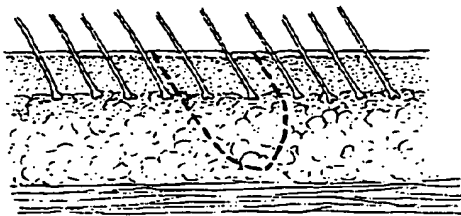
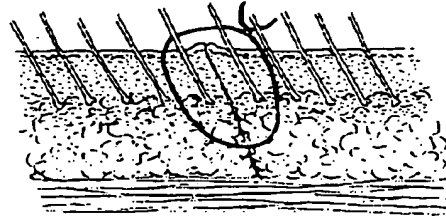
c

tie

**SCALP REPAIR****Figure 1-5**

- a. In resection of lesions of the scalp or resections of the scalp in meloplasty and rhytidectomy procedures, the incision should be beveled away from the hair roots. The scalpel is angled so that the incision progresses deeper toward the area to be resected, rather than undercutting in the opposite direction, as with the usual scar resections in non-hair-bearing areas. This preserves the hair roots in the edges of the incision and allows for hair growth right up to the fine line of the resulting scar. By beveling both incision lines toward the area to be resected, the hair roots are present close to the incised edges, and hair growth is usually little disturbed.
- b. Closure of the incision brings the hair roots, and thereby the hair growth, very close to the incision line. This makes it easy to mask the fact that an incision has been made in the scalp and usually leaves no visible evidence that a scalp resection has been carried out. This is especially important in the meloplasty and rhytidectomy procedures.

Also, in order to avoid disturbing the hair roots, a layer closure is seldom carried out in the scalp. However, a deep closure of the pericranium and occipitofrontalis layers may be done, so that the buried sutures do not damage the hair roots in the dermis and the immediate subcutaneous fat of the scalp.

**a****b****1-5**

# THE SUBCUTICULAR SUTURE AND THE RUNNING CONTINUOUS SUTURE CLOSURE

**Figure 1-6**

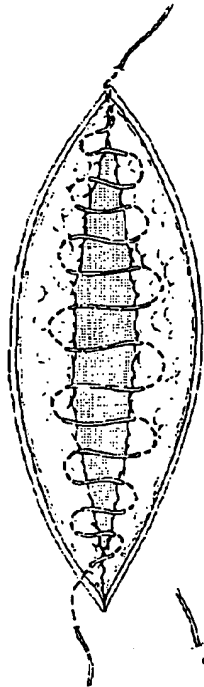
a. Step 1: This consists of placement of a deep-running, single-filament suture which grasps bites of tissue alternately on the two sides of the depths of the wound. Ordinarily, the suture is brought out at some point along the incision line if the wound is long and is brought out beyond the ends of the incision. Pulling the ends of the suture tightly closes the depths of the wound, as seen in step 2. For more superficial wounds or for those wounds which have been closed with multiple interrupted, deep-buried sutures, the intracuticular or subcuticular suture may be used similarly for the final skin closure.

b. Step 2: The deep running suture has been tightened by pulling each end, which approximates the deeper tissues. The superficial running suture has been placed, but has not been put under tension. Multiple running sutures may be used in this fashion for wound closure in lieu of buried interrupted sutures. The more superficial subcuticular or intracuticular suture may be left in place for an extended period for support, since it does not leave stitch marks.

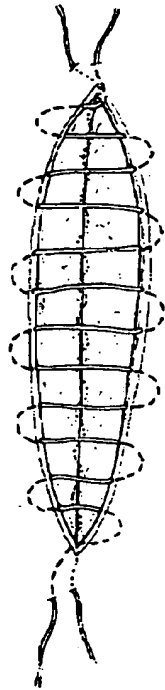
c. Step 3: Completion of the multiple continuous suture closure of the wound. The multiple continuous running sutures (in this case, two layers of closure) may be tied together over a bolus of gauze, rubber sponge, or rubber drain at each end of the incision when it is deemed necessary to keep the sutures tight for support. However, the support of the running sutures themselves generally is adequate without their being tied.

Later, removal of the continuous running suture is facilitated by a loop to the side of the incision or across the incision. This loop is usually kept loose so that it does not cut in and leave a stitch mark. The continuous running suture closure avoids the use of foreign suture material in the wound, and the sutures may be left in place for an extended period without danger of leaving stitch marks.

bites of tissue (penetrates tissue)



a



b

after they have been buried or penetrated with needle & suture on needle

c

1-6

N.B. \* ties not needed to approximate suturing is needed tissue is needed

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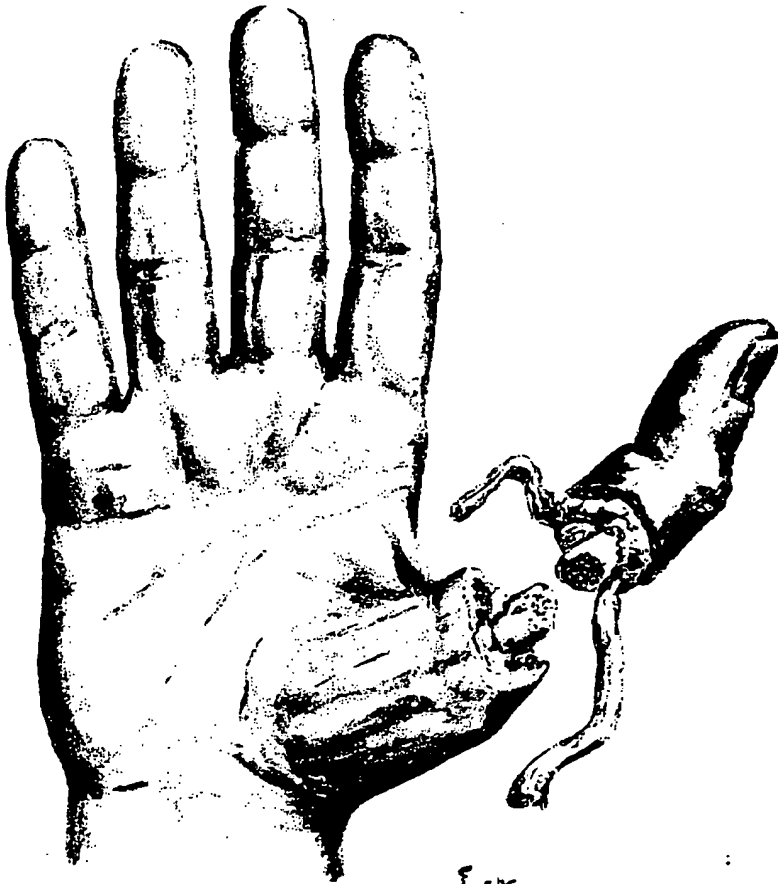
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Volume 43 Number 2 1991

Reprint

## Replantation

Harold E. Kleinert, MD  
James M. Kleinert, MD  
Steven J. McCabe, MD  
Anthony C. Berger, MBBS



*F. Netter*  
M.D.  
OCALA-GENCO

# CLINICAL SYMPOSIA

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Edited by Kristine J. Bean

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*Maria Erdélyi-Brown, Managing Editor*

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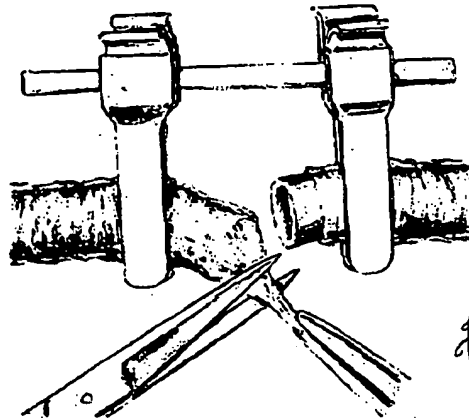
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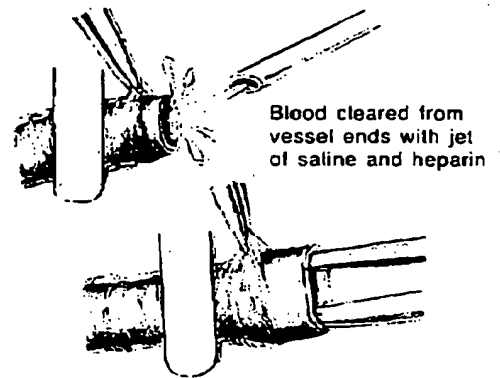
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Plate 9

## Repair of Blood Vessels and Nerves

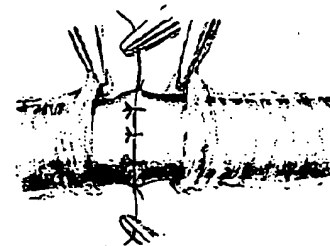


Under dissecting microscope, vessel ends positioned in approximation clamps. Adventitia removed by pulling it down over vessel end, cutting it, and letting it draw back

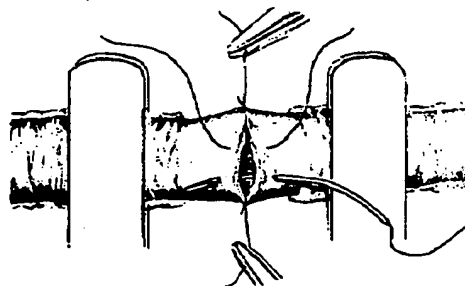


Blood cleared from vessel ends with jet of saline and heparin

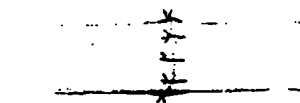
Vessel ends dilated 1½ times normal diameter



Veins anastomosed using similar technique; because veins are so fragile, great care must be taken. Clamps may be used very cautiously



Gaps between stay sutures closed with interrupted sutures. Vessel turned over for suturing back wall. For large arteries, running suture used, avoiding purse stringing. In areas where clamp does not fit, back wall repaired first with top of vessel and lumen in view at all times



Since digital nerves contain only sensory fibers, repaired with simple sutures through epineurium only

*through tissue*

not revascularize following major vessel repair. Similarly, amputations at the metacarpal level require resection of the distal avascular intrinsic muscles (Plate 12).

Regional anesthesia is preferred except for very proximal replantations, which require general anesthesia. The stump is debrided and the bone shortened (page 16). Amputations at the forearm level or higher usually result from more violent injury than finger amputations, so the zone of injury is larger. Consequently, the

amount of bone resected (2-4 cm) is greater than for replantation of fingers. For wrist joint replantations, however, as little bone as possible is resected in order to preserve midcarpal or radiocarpal wrist motion.

If ischemia time is prolonged, a shunt may be placed between the proximal and distal arteries and veins to perfuse the limb as quickly as possible. The first venous effluent from the severed limb is discarded because it contains high levels of potassium, lactic acid, and myoglobin. The

# PRINCIPIALIZATION OF PLASTIC SURGERY

D. RALPH MILLARD, Jr., M.D.



# PRINCIPLIZATION OF PLASTIC SURGERY

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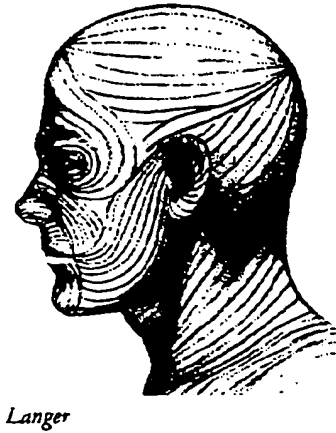
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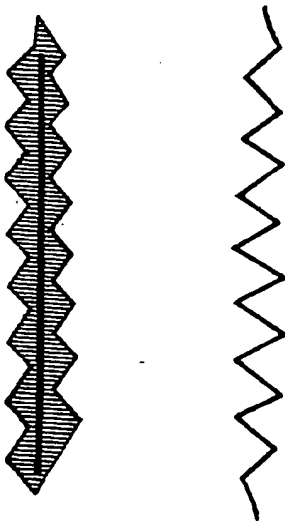
the mouth, the upper lip and the lower lateral chin. On the body, scars become adherent to the underlying tissue; hence they will least interfere with body dynamics if placed transversely across muscles and joints in wrinkle lines. In excising a lesion on the skin one should plan incisions to have the resultant scars fall in these wrinkles. A. F. Borges has labeled these lines relaxed skin tension lines and he advises how to find them: "The R S T L can be found by relaxing the skin of a region either by some kind of muscle pull, by joint mobilization or, better, by passive manipulation."



## TENSION VERSUS SCARS

Success with improving scars in the normal is dependent in large part on an understanding of the main enemy, tension, and an ability to compromise its deleterious effects during healing. First it is essential to know the relaxed skin tension lines.

Albert F. Borges' contribution to the improvement of scars is based on a thorough understanding of skin tension (bull) and how best to handle it (matador). It is true that the W-plasty described by Borges in 1958 and 1959 increases the amount of advancement required for wound closure by double the depth of the sawtooth, but the advantages to having scars lie in anti-tension lines are the camouflage of a broken line too busy for the eye to record easily and the eventual elasticity of its multiple interdigitations. Here are some of Borges' primary rules.



[1] An elective surgical incision that follows the relaxed skin tension lines will give the best cosmetic and functional scar.

[2] For an antitension line (ATL) surgical exposure, a zig-zag skin incision is superior to a straight ATL incision since it will give a wider exposure and a superior accordion-line elastic postoperative scar.

[3] Antitension line scars are improved with the zig-zag scar revision procedures (W- or Z-plasty) mainly by changing the scar's direction and by dividing the scar into smaller straight components. Any scar on the face that does not follow the relaxed skin tension lines (RSTL) can be improved with either a W-plasty or a Z-plasty scar revision provided there has not been a previous appreciable amount of skin loss.

[4] Skin tension, influenced by the amount of skin loss, region, course, pattern and length of the scar and age of the patient, is the basic factor underlying the outcome of scars.

[5] Wide and/or hypertrophic scars, most of the time, are not amenable to any scar revision procedure. The simple excision of a wide and/or hypertrophic scar that has resulted during healing by primary intention of a wound and the subsequent closure of the defect created (fusiform scar revision) will inevitably be followed by a wide and/or hypertrophic scar.

[6] Do not revise a scar unless you are reasonably certain to be able to change, all or in part, the factors responsible for the unsatisfactory outcome or you chance the possibility of the revision turning out worse than the original scar.

[7] When confronted with a severely depressed scar or a bowstringed elevated scar, the Z-plasty is the procedure of choice because of its outstanding levelling effect by interdigitation of tissue gains to interrupt the direction of tension.

[8] In the correction of the trap door scar deformity the treatment should not be aimed at the bulging enclosed tissue of normal subcutaneous fat but at the beltlike contraction of the curved skin scar.

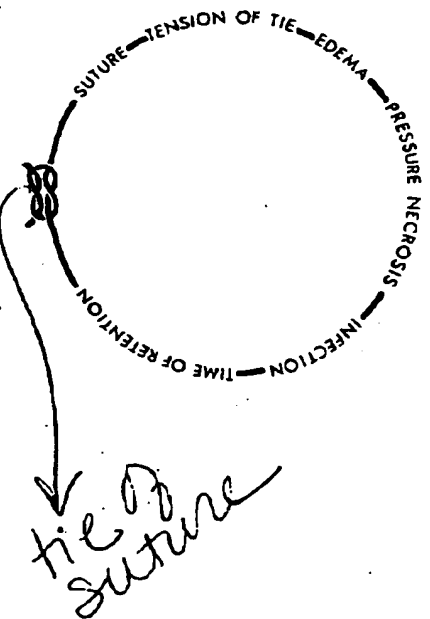
[9] The most frequent blunder in suturing technique is the tying of skin sutures too tight.

William S. Halstead at Johns Hopkins Hospital in 1890 warned, "The obstruction to the circulation produced by sutures and ligatures is often the immediate cause of suppuration in infected wounds."

## BEWARE TENSION STITCH MARK

The tension cycle can occur in miniature during the placement of sutures. Whereas scars resulting from lacerations and incisions are inevitable, permanent stitch marks are avoidable. Like a beast tracked by the print of his claw, the surgeon is known by the mark of his sutures. If by these tracks we are to be known, it behooves us to scrutinize this potentially vicious cycle of suture.

If the stitch loop is cinched too tight in the tie, not only will it cut skin but inflammatory edema will force ischemia, which will soon cause necrosis, attracting bacteria, which eat away as long as the foreign body suture is retained until the stitch hole becomes a permanent ugly scar mark. Prevent stitch marks by not tying the suture too tight, keeping the wound clean, covering the stitch holes with an antibiotic ointment and removing the sutures early—3 to 4 days on the face, no longer than 5 or 6 days on the body. If the wound suffers enough tension to require



Fenton Braithwaite of Newcastle refined the sophistication of palate surgery by freeing the levator palatini muscles from their attachments to the posterior edge of the hard palate and suturing them with their fibers end-on to construct a repositioned levator loop without tension for a better-functioning unit.



The hand surgeon is acutely cognizant of the danger of tension. As Harold Kleinert wrote in 1983:

The surgeon's greatest enemy is scar tissue. Scar is stimulated by wound tension. Avoidance of scar requires avoidance of tension, whatever the repaired tissue—tendon, nerve or blood vessel. The first surgeon to operate has the best chance of returning function and more than anyone else determines the ultimate outcome of an injury. Complex multiple tissue injuries are best repaired initially and preferably completely. Bone fixation must be secure. In addition to tendons repaired, joints, ligaments, blood vessels and nerves must be protected against tension. \*

Fixation  
dying  
rotating  
securing

H. Millesi et al. stated in 1972 that tension at the suture line of a nerve repair is detrimental. In 1977 Millesi showed that nerve grafting produces better results than direct suture because tension interferes with the blood supply within the nerve. Julia K. Terzis noted in 1984:

The rule of thumb is: after adequate nerve end preparation, if the nerve ends can be approximated adequately with minimal tension with an 8-0 suture, then the necessity of interposition grafting is eliminated.

In microvascular surgery any tension promises disaster, and development of methods of avoiding tension has been responsible for much of the progress of this specialty. As Harry Buncke of San Mateo, California, commented:

The most important principle in microvascular surgery is flawless microvascular technique. The most elegant transplant is doomed to failure if circulation cannot be re-established in the transplanted part. The microvascular

## USE OF TENSIONS IN EYELID REPAIR

A defect involving one-third full thickness of the eyelid margin can be closed by direct approximation. If as much as half the eyelid margin must be sacrificed, a lateral canthoplasty will be necessary to advance ciliary margin, muscle and conjunctiva to allow the vertical closure without too much tension and distortion. A simple procedure I described in the *American Journal of Ophthalmology* in 1958 positioned the direction of scars and employed to advantage the relative tensions of closure to avoid vertical skin scars, marginal notching and lid ectropion. In case of a carcinoma the resection was restricted to the lesion and an adequate margin in the skin. The excision was extended to a V only in the mucomuscular layers to allow their direct closure in a vertical line with 5-0 chromic catgut sutures in the muscle and submucosal tissue, avoiding exposure on the conjunctival side. A horizontal blepharoplasty incision in the skin just under the lower lid lashes or just above the upper ones is extended in both directions almost canthus to canthus. The eyelid skin is freed from the underlying muscle, and the center point of the edge of the skin defect is lifted and stitched to the ciliary margin. The excess free skin is excised as a pair of triangles (crosshatching).

stitched =  
sutured

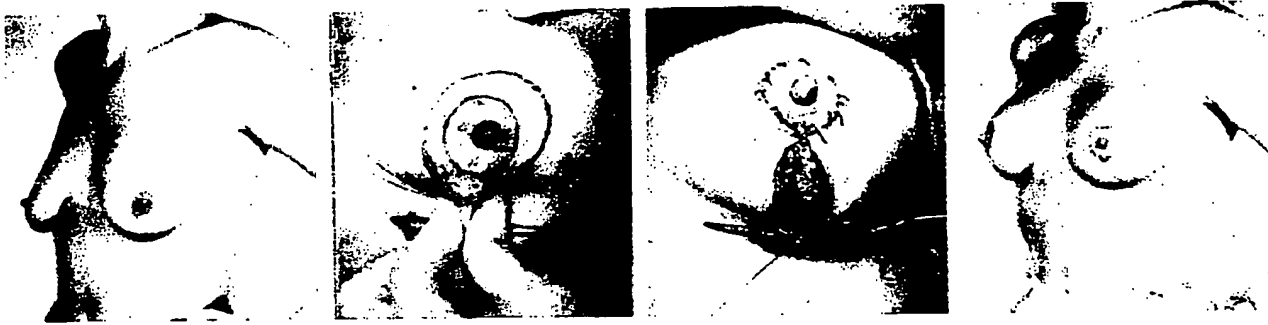


The result is a relatively straight advancing skin edge that can be raised (lower lid) or lowered (upper lid) like a curtain and sutured along the ciliary margin in a horizontal, hidden scar. The moderate side-to-side tension of the vertical mucomuscular closure creates the bonus of a relatively tight margin span that can



## BREAST LIFT

The vertical skin excision in reduction mammoplasty and lift mastopexy with vertical closure of the central wedge places the greatest tension along the inframammary line with effective lifting and coning of the breast. When more substance is needed



for breast contour, small implants can be inserted at the same time. This takes advantage of tension in two dimensions: outward projection and inframammary cinching. Beware the summation effect on the vertical scar.

## ABDOMINAL LIPECTOMY

Abdominal slack is another area where tension can be used to advantage. The abdominal lipectomy through a transverse supra-pubic incision frees the abdominal panniculus off the rectus fascia up as high as the costal margin. The umbilicus is circumscribed by an incision and maintained on its pedicle. If indicated, mid-vertical plication of the rectus fascia with nonabsorbable suture above and below the umbilical stalk is another use of tension to improve the transverse supporting tone of the abdominal wall. All excess abdominal skin that can be spared is excised, and when possible the skin just above the umbilicus is advanced under reasonable tension to the pubis in a transverse closure. If there is not enough slack to allow this extensive transverse elliptical excision, less can be taken and a V excision of the remaining umbilical hole can be closed vertically in an unnoticeable inverted T, which also reduces lateral excesses.

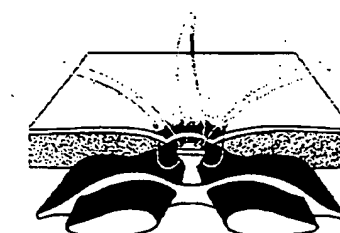
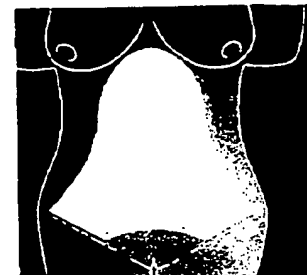
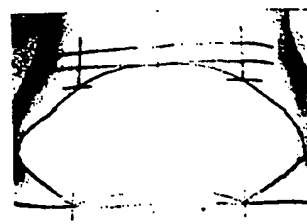
This has always seemed a simple procedure, but it is enlightening to see how Ricardo Baroudi of Campinas, Brazil, who is enthusiastic about his work, handles the markings, the dissection, the umbilicus, the excisions and the closure while dealing with tension and ensuring symmetry. Here is a 41-year-old woman with moderate abdominal lipodystrophy, striae and flabbiness of skin who was treated by Baroudi. He explains in detail:

A vertical midline mark from xyphoid to pubis assured symmetry of final umbilical position. A straight horizontal line near the mons pubis combined with an open W-line from one anterior iliac spine to the other marks the line of incision which follows the W-line. Three transverse and parallel lines are drawn bilaterally at the umbilical level. When the abdominal flap is pulled downward these reference points must be symmetrical. The area of flap undermining on the fascial level is diagrammed in white limiting lateral dissection to avoid severance of vessels. After circumscribing the umbilicus on its pedicle the abdominal flap is freed, pulled down and cut vertically in the midline up to the umbilical hole. The flap is elevated and the rectus fascia plicated with 2-0 nylon sutures.

With a Kelly clamp attached to the umbilical pedicle, one hand is placed under the skin flap and guided by the clamp locates the exact future position of the umbilicus. A transverse burrhole is stabbed in the abdominal flap, the flap is everted and a small circular area of fat around the hole is resected.

*(photo)* For umbilical fixation two to four 2-0 nylon sutures are placed around the clock with a bite through abdominal skin, fascia near the root of the umbilical pedicle and skin edge of the umbilical cuff. When these sutures are tied down the skin invaginates creating a natural umbilical contour.

With the trunk elevated the midline key stitch is placed and followed with bissection of the excess overlapping skin flap to allow another key stitch on each side. The excess skin is excised.



Eight-year follow-up

If the abdominal flap is thick it can be defatted and resutured. The umbilical sutures are tightened over a gauze pad. Approximation of this wound under moderate tension requires a three layer closure, fat to fat, fascia and fat, dermis and finally intracuticular 4-0 Vicryl reinforced with steri-strips and an elastic girdle to protect the trunk.

MATSEN  
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HARRYMAN

Practical Evaluation  
and  
Management  
of the Shoulder

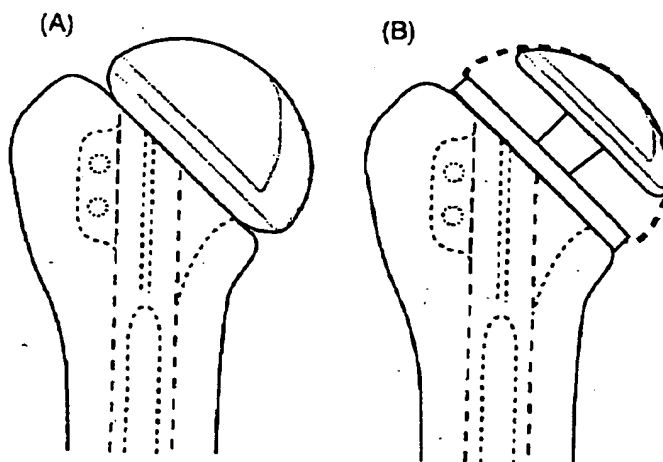
*Fixation*  
 sculpting. This precision is enhanced by a glenoid reamer keyed to the normalized glenoid center line. The use of a drill guide to establish precise geometry for multiple glenoid fixation pegs may provide better fixation with minimal sacrifice of glenoid bone stock and requires minimal amounts of cement with minimal risk of heat necrosis. Fixation anterior and posterior to the vertical axis of the glenoid component helps prevent "lift off" during eccentric loading. As presented earlier in this chapter, there are theoretical advantages of a small degree in undersizing of the humeral diameter of curvature with respect to that of the glenoid. The relative clinical advantages of different degrees of humeroglenoid diameter mismatch are yet to be determined.

Multiple considerations affect the choice of the humeral component as well. Good fit and fill of the humerus can often provide secure fixation without cement, but press fitting does increase the risk of humeral fracture. Whether the medullary canal needs to be sealed to prevent entry of polyethylene debris remains a theoretical consideration. The humeral head needs to provide the appropriate diameter of curvature in both humeral and glenohumeral arthroplasty. In humeral hemiarthroplasty, the diameter of curvature should match that of the biologic

articular surface. In glenohumeral arthroplasty, the diameter of curvature should be appropriate for the glenoid component selected. The arc subtended by the humeral articular surface should be maximized rather than having part of this arc sacrificed to a non-articular humeral neck (Fig. 5-39). Canal-fitting prostheses allow less flexibility in positioning: the reamed canal largely controls the medial-lateral, anteroposterior, and varus-valgus degrees of freedom. Thus, the surgeon needs to ensure that the selected prosthesis will provide the appropriate effective neck length and component height to establish the desired position of the articular surface. Ideally, the humeral prosthesis should restore the joint surface to its anatomic location.

### Technique of Glenohumeral Arthroplasty

Glenohumeral arthroplasty provides the surgeon with the opportunity to use all the principles related to the restoration of motion, strength, stability, and smoothness. All adhesions and contractures must be released, and the smoothness of the non-articular humeroscapular motion interface must be reestablished. Obligate translation is avoided by appropriate capsular releases.



S. Lippitt, M.D.

FIGURE 5-39.

A. Ideally, the humeral component provides a maximal articular surface area. B. Significant portions of the intraarticular space can be consumed by non-articular aspects of a modular prosthesis.

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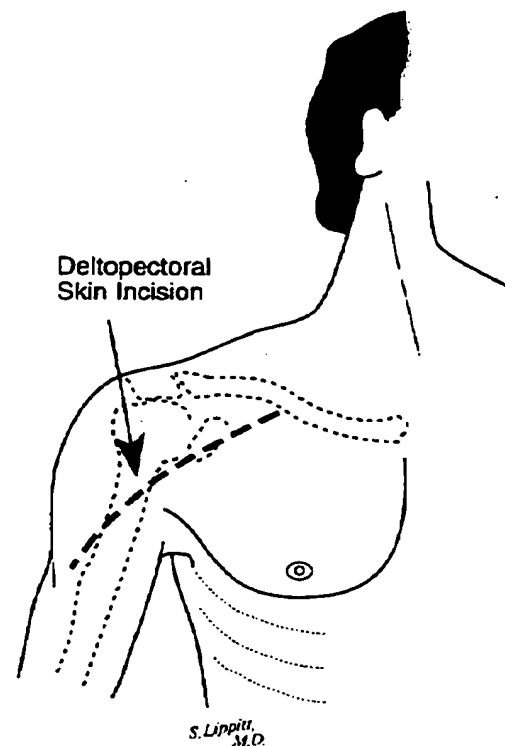
Strength is optimized by placing the muscle-tendon units under proper tension. Stability is achieved by normalizing joint surface orientation and providing the appropriate geometry for the concavity compression stabilization and balance mechanisms. Smoothness is provided by the prosthetic joint surfaces and by immediate postoperative motion.

### ***Surgical Approach***

After a brachial plexus block or general anesthetic, the patient is placed in the beach chair position with the thorax up at an angle of 30 degrees. The shoulder is just off the edge of the operating table so it can be moved freely through an entire range of motion. The anesthesiologist is positioned at the side of the neck on the opposite side from the shoulder being operated on. A careful double skin preparation includes the entire arm and forequarter, anteriorly and posteriorly. Draping allows access to the entire scapula, clavicle, and humerus.

**Skin Incision.** This is made over the deltopectoral groove along a line connecting the midpoint of the clavicle to the midpoint of the lateral humerus and crossing over the coracoid process (Fig. 5-40). This incision avoids the axilla, protects the neurovascular supply to the deltoid, and provides direct access to the deltopectoral interval without requiring skin flaps. Gelpi retractors placed in the subcutaneous tissue help provide hemostasis as the incision is carried to the level of the deltopectoral fascia. The deltopectoral interval is developed medial to the cephalic vein, preserving its major tributaries from the deltoid muscle. Incising the clavipectoral fascia at the lateral edge of the conjoint tendon up to, but not through, the coracoacromial ligament provides entry to the non-articular humeroscapular motion interface. The axillary nerve is identified as it courses across the inferior border of the subscapularis.

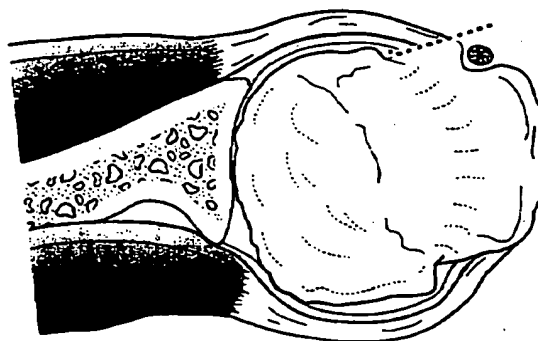
The subscapularis is the one tendon incised in performing a glenohumeral arthroplasty. Restoring the excursion of this ten-



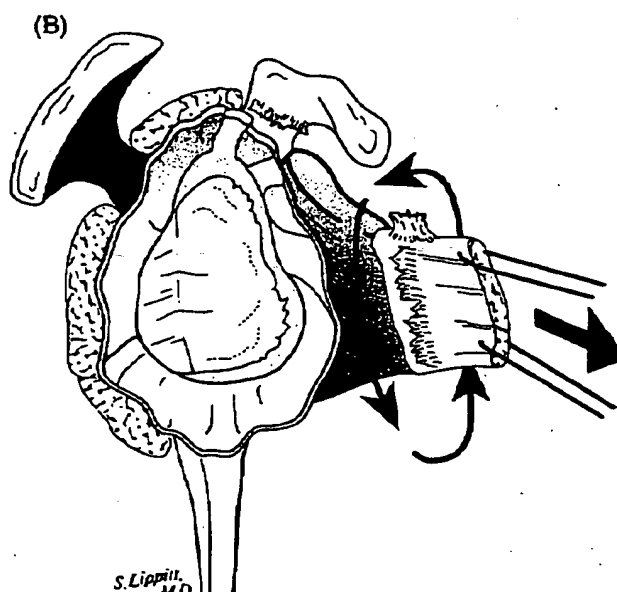
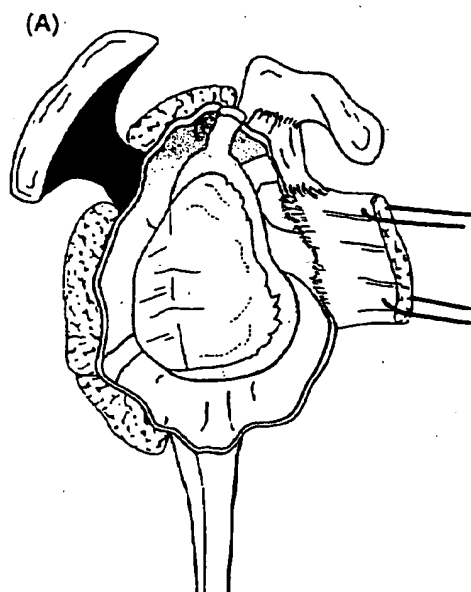
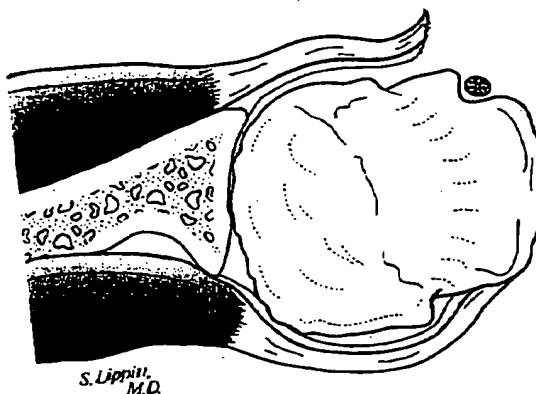
**FIGURE 5-40.**

Anterior deltopectoral skin incision extending along a line from the midpoint of the clavicle to the midpoint of the lateral humerus (deltoic tubercle). Note that this line of incision crosses the coracoid tip.

don as well as its firm reattachment to the humerus is critical to the restoration of the range, stability, and strength of the shoulder. Our routine is to incise the subscapularis tendon as close to the bicipital groove as possible to gain maximal length of quality tendon; no subscapularis tendon is left on the lesser tuberosity. The anterior glenohumeral capsule is incised from its attachment to the glenoid and is left attached to the deep surface of the tendon to reinforce it (Fig. 5-41). A 360 degree release of the subscapularis tendon is then performed (Fig. 5-42), ensuring that it moves freely with respect to the glenoid, the coracoid, the coracoid muscles, the axillary nerve, and the inferior capsule. Additional subscapularis length is gained at the time of closure by reattaching it with sutures placed in the anterior humeral neck rather than the lesser

**FIGURE 5-41.**

The subscapularis incision. The subscapularis and the subjacent capsule are incised directly from the lesser tuberosity, striving for maximal length of the tendon.

**FIGURE 5-42.**

Mobilization of the subscapularis tendon. *A*, Attachment of the subscapularis tendon and capsule to the coracoid and glenoid. *B*, A complete 360-degree release about the subscapularis tendon optimizes muscular excursion and functionally increases the length of the subscapularis.

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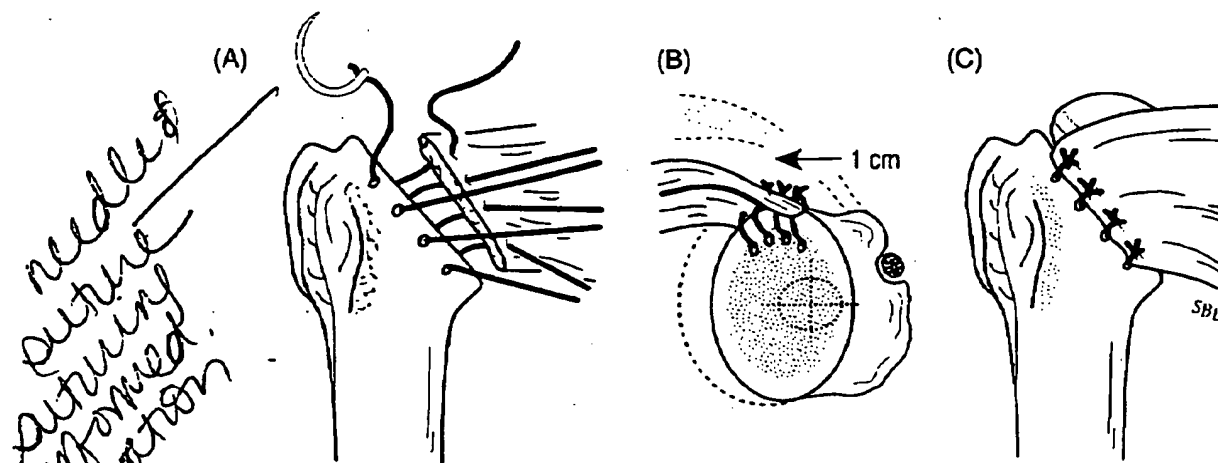


FIGURE 5-43.

The subscapularis is closed to the neck of the humerus rather than to the lesser tuberosity from which it was originally incised. This results in an effective lengthening of the tendon.

tuberosity (Fig. 5-43). If still more length is needed, an inside-out coronal plane Z-plasty can be performed, using the capsule to extend the tendon (Fig. 5-44). Each centimeter of subscapularis lengthening provides approximately 20 degrees of increased external rotation.

The capsule remaining on the anterior glenoid is excised along with any residual labrum. With a finger protecting the axillary nerve, the inferior capsule is incised from the glenoid, exposing the origin of the long head of the triceps (Fig. 5-45). Occasionally, if triceps contracture impedes motion, the

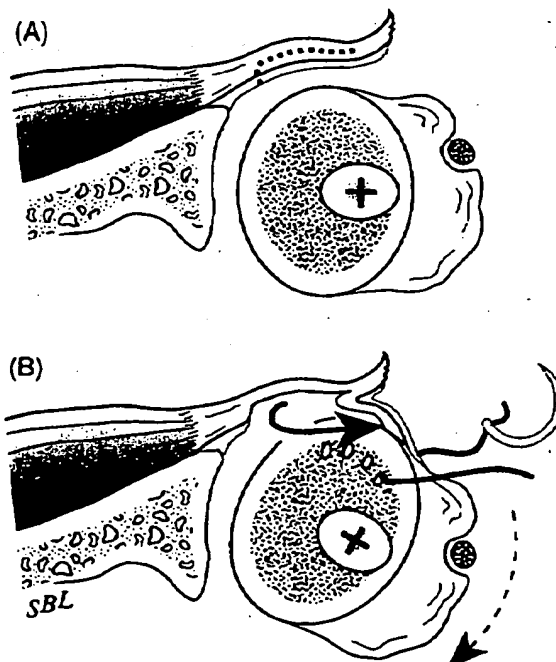


FIGURE 5-44.

The inside-out Z-plasty. A, Additional length of the subscapularis tendon can be gained by splitting the capsule from the tendon medially, leaving their connection laterally. B, The medial end of the split capsule is reflected and attached to the humeral neck.

via suture & needle.

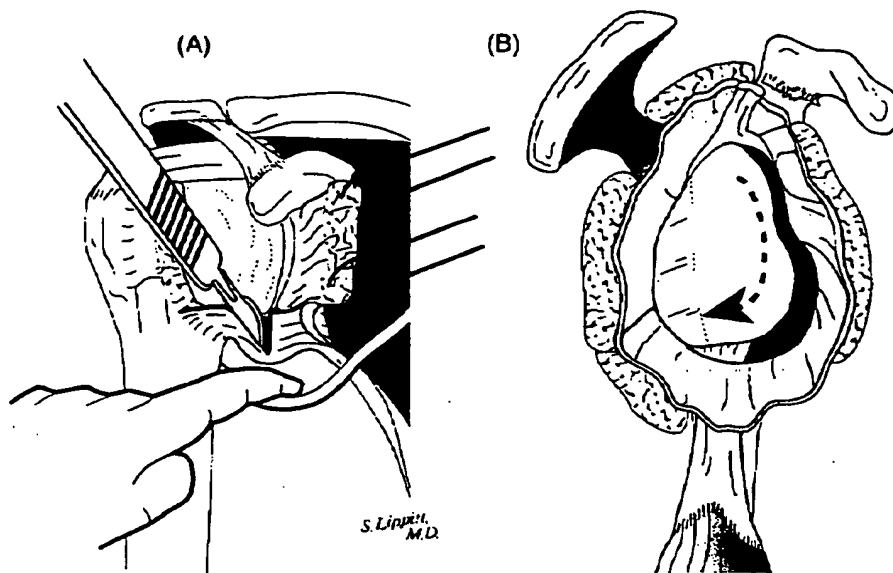


FIGURE 5-45.

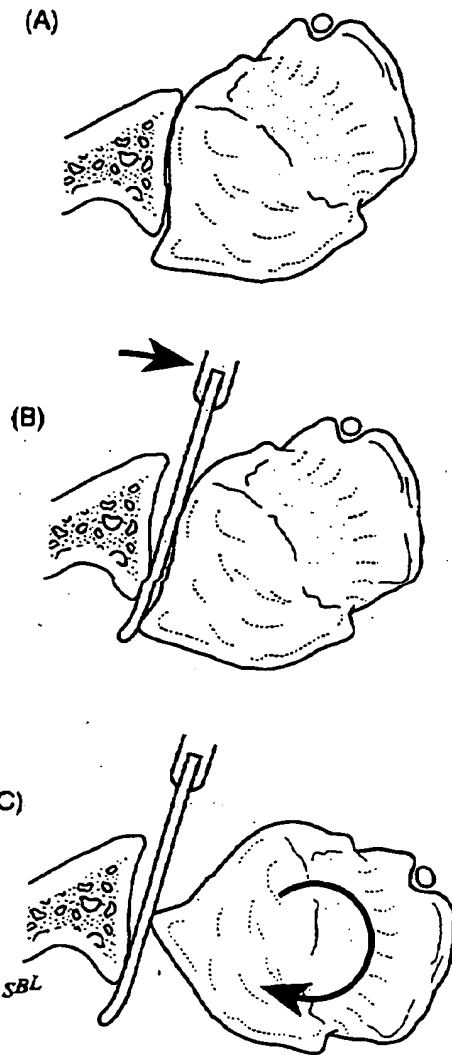
A, Division of the anteroinferior capsular attachments to the glenoid under direct vision while axillary nerve is protected and retracted. B, Capsular release to the 6 o'clock position on the glenoid exposes the origin of the long head of the triceps, which may require release as well.

triceps origin may need to be released in a manner similar to the adductor release in hip arthroplasty. If the posterior capsule is tight, it can be released later under direct vision after the humeral head has been excised. Posterior capsular release should not be performed if there is preoperative evidence of posterior subluxation.

**Humeral Preparation.** The humeral head is dislocated anteriorly by *gentle* external rotation and slight extension of the arm. Special care is exercised in elderly patients and in those with rheumatoid arthritis or other causes of fragile bone. Any resistance to this maneuver indicates the need for additional soft tissue release. Posterior humeral head osteophytes can impede the dislocation maneuver by impinging on the glenoid as the humerus is externally rotated. This phenomenon is suggested if the glenohumeral joint opens anteriorly like a book as the humerus is externally rotated. Often, in this situation, the humeral head along with the osteophytes can be safely and gently lifted into the joint with a flat elevator used as a "shoe

horn," inserted while the humerus is internally rotated (Fig. 5-46). A malunited greater tuberosity or large osteophytes may require osteotomy. By incorporating the movements of external rotation, anterior subluxation, and extension of the arm, the articular surface of the humerus is brought into view.

The humeral osteotomy requires attention to detail. In degenerative joint disease, the apparent articular surface does not provide an accurate indication of the plane of humeral head resection. Failure to account for the apparent elongation of the articular surface by inferior osteophytes results in an inordinately vertical (varus) resection level (Fig. 5-47). An excessively inferior or retroverted plane of resection jeopardizes the greater tuberosity and the insertion of the rotator cuff. To avoid these pitfalls, the humeral cut is based on readily identifiable landmarks. The ideal cut plane passes just inside the supraspinatus insertion to the tuberosity, at an angle of 45 degrees with the long axis of the shaft, and in 35 degrees of retroversion as judged by the external rota-

**FIGURE 5-46.**

Large posterior humeral osteophytes can form a barrier to external rotation and dislocation of the humeral head at arthroplasty surgery (A). Reduction of large posterior osteophytes onto the glenoid face can usually be accomplished by placing a smooth retractor through the joint while the humerus is in internal rotation (B) and then gently externally rotating the humerus (C).

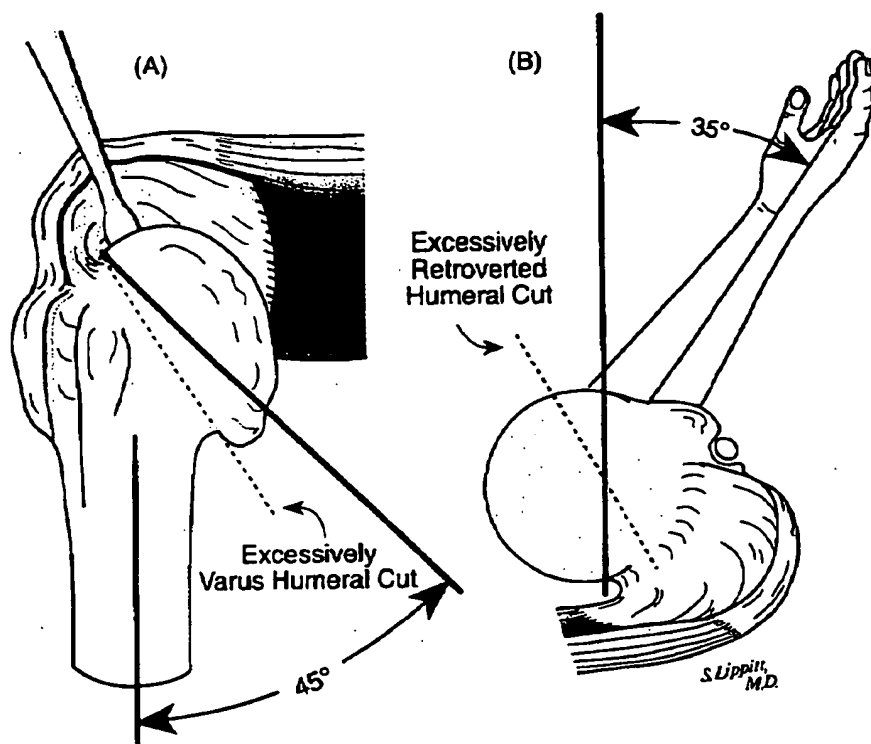


FIGURE 5-47.

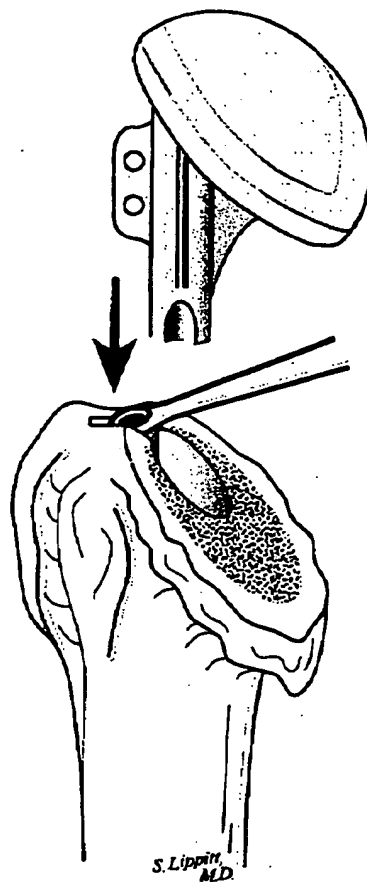
Humeral osteotomy planes. A, The preferred osteotomy plane passes just inside the insertion of the rotator cuff to the greater tuberosity and proceeds at a 45-degree angle with respect to the long axis of the humeral shaft. If the osteotomy is incorrectly oriented such that it emerges at the margin of the osteophytes (dotted line), the resulting cut will be in excessive varus. B, Humeral osteotomy also requires careful attention to version. An excessively retroverted cut (dotted line) compromises the cuff insertion.

tion of the forearm with the elbow flexed to a right angle. Cutting the head under direct vision with an osteotome while protecting the cuff with a blunt elevator facilitates verification of the plane and safety of the cut. Throughout the osteotomy, the cuff insertions and the biceps tendon are protected and observed as the osteotome passes by.

At this point the surgeon has an opportunity to judge the laxity of the joint. By placing the arm in 45 degrees of elevation and by using a finger to push the humeral neck laterally, the surgeon can get an idea of the joint volume remaining for the glenoid and humeral head component. This step is helpful in determining the need for further soft tissue balancing. If the capsule is so tight that even the smallest head will not fit, more release is required. Cutting away more neck

is not an option because the humeral cut is already at the cuff insertion.

The medullary canal of the humerus is reamed, starting at a point lateral on the cut surface just behind the bicipital groove. Starting with a small-diameter reamer, reaming is continued up to the diameter appropriate to the component, using a slight valgus bias and while protecting the biceps and cuff. Slots are made in the tuberosity to accommodate the fins of the component. The slot for the lateral fin should be just posterior to the bicipital groove (Fig. 5-48). In the presence of dense bone, failure to achieve adequate depth of these slots may result in the component being pushed into a varus orientation by contact between the fin and the bone of tuberosity. A trial component body is inserted so that the prosthetic neck

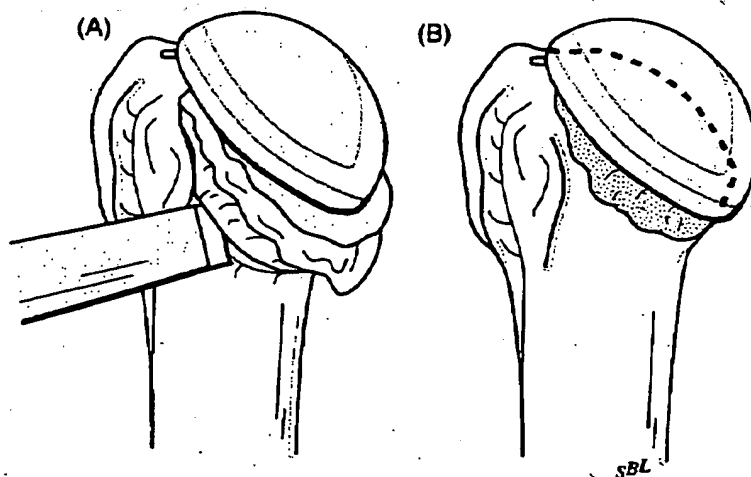
**FIGURE 5-48.**

Before implantation of the trial component, a slot is curetted in the tuberosity just posterior to the bicipital groove to accommodate the fin of the trial component.

is centered on the neck of the bony head, being neither too high (where the component will lead to excessive tension on the superior cuff), nor too low (where the component will lead to subacromial abrasion of the rotator cuff on elevation of the arm). The trial component is used as a guide to the extent of the osteophytes all around the humeral head (Fig. 5-49). The rotator cuff, axillary nerve, and glenoid are protected during osteophyte excision.

While the trial humeral head is in place, the surgeon can verify that there is sufficient subscapularis length to allow 40 degrees of external rotation and adequate posterior stability as indicated by 70 degrees of rotation of the arm elevated to 90 degrees in the coronal plane ("scarecrow" position) and 15 mm of translation on the pull-drawer test. If the joint is too tight with the trial head component alone, it will be tighter after the glenoid is inserted. If necessary, additional capsular releases are performed at this stage to achieve the desired laxity. Additional posterior capsular release may be accomplished by incising the capsule at the glenoid rim while the capsule is held in tension by a proximal humeral tractor (Fig. 5-50). Care is taken to protect the axillary nerve below and the circumflex humeral artery behind.

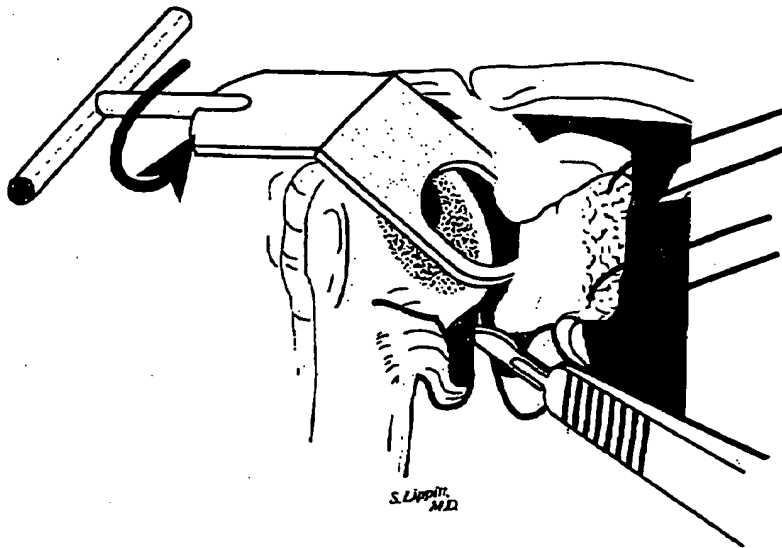
With the trial humeral component moved and the proximal humerus displaced medially into the joint, the rotator

**FIGURE 5-49.**

A, Trial prosthetic head seated against bone where it can serve as a guide for resecting any anterior, and posterior osteophytes that extend beyond the extrapolated articular surface. B, Osteophytes resected from the anterior, inferior, and posterior humeral neck. Posterior osteophytes must be removed with great care to protect rotator cuff insertion.

**FIGURE 5-50.**

If necessary, the sequential posterior release is accomplished by incising the capsule at the glenoid rim (release at the humerus would jeopardize the cuff insertion). During this release, the capsule is tensed by twisting the humeral retractor. Care is taken to protect the axillary nerve below and the cuff behind.

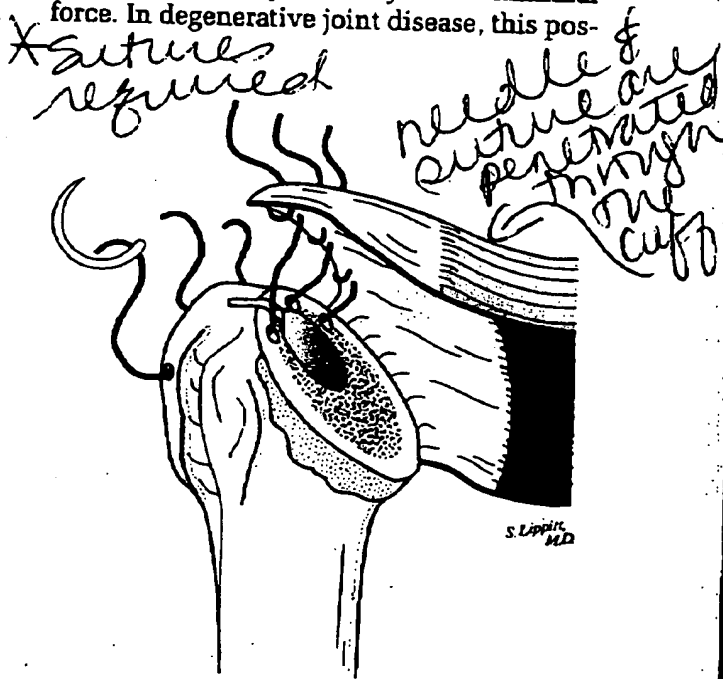


palpated to establish its integrity. If a repairable defect involving quality cuff tissue is identified, the retracted tendon is mobilized so it can reach the tuberosity without undue tension with the arthroplasty components in place. Sutures are placed in the edges of torn cuff tendon and through drill holes in the tuberosities for later tying after the components have been implanted (Fig. 5-51). Shorter humeral head components may facilitate cuff repair without undue tension. Cuff repair in association with shoulder arthroplasty tightens the joint and slows the rehabilitation. Thus, the surgeon must ensure that the repair is strong and durable. Suturing of poor-quality tendon or attempting repairs when insufficient tissue is present is not advised.

Tuberosity non-unions should be identified and mobilized at this point. Severe tuberosity malunions should be osteotomized; however, this should not be performed lightly: gaining tuberosity union can be difficult in the presence of a metal humeral component, diminished bone stock, and soft tissue contractions.

**Preparation of the Glenoid.** Accurate preparation of the glenoid bone requires the excellent surgical exposure provided after humeral head and osteophyte excision and capsular release. A flat retractor is placed behind the posterior glenoid lip to push the

head of the humerus posteriorly. When the resected surface of the humeral neck is flat against the back of the retractor (the arm externally rotated 35 degrees), the humerus can be pushed posteriorly with minimal force. In degenerative joint disease, this pos-

**FIGURE 5-51.**

Repair of a rotator cuff tear. If tissue is adequate for repair, drill holes are placed in the tuberosities for cuff attachment before the insertion of the humeral component.

MATSEN  
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HARRYMAN

# Practical Evaluation and Management of the Shoulder

*fixation*  
 \* sculpting. This precision is enhanced by a glenoid reamer keyed to the normalized glenoid center line. The use of a drill guide to establish precise geometry for multiple glenoid fixation pegs may provide better fixation with minimal sacrifice of glenoid bone stock and requires minimal amounts of cement with minimal risk of heat necrosis. Fixation anterior and posterior to the vertical axis of the glenoid component helps prevent "lift off" during eccentric loading. As presented earlier in this chapter, there are theoretical advantages of a small degree in undersizing of the humeral diameter of curvature with respect to that of the glenoid. The relative clinical advantages of different degrees of humeroglenoid diameter mismatch are yet to be determined.

Multiple considerations affect the choice of the humeral component as well. Good fit and fill of the humerus can often provide secure fixation without cement, but press fitting does increase the risk of humeral fracture. Whether the medullary canal needs to be sealed to prevent entry of polyethylene debris remains a theoretical consideration. The humeral head needs to provide the appropriate diameter of curvature in both humeral and glenohumeral arthroplasty. In humeral hemiarthroplasty, the diameter of curvature should match that of the biologic

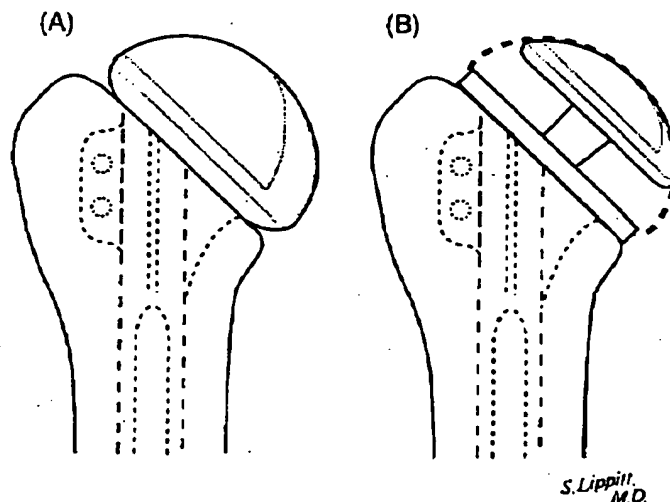
articular surface. In glenohumeral arthroplasty, the diameter of curvature should be appropriate for the glenoid component selected. The arc subtended by the humeral articular surface should be maximized rather than having part of this arc sacrificed to a non-articular humeral neck (Fig. 5-39). Canal-fitting prostheses allow less flexibility in positioning; the reamed canal largely controls the medial-lateral, anteroposterior, and varus-valgus degrees of freedom. Thus, the surgeon needs to ensure that the selected prosthesis will provide the appropriate effective neck length and component height to establish the desired position of the articular surface. Ideally, the humeral prosthesis should restore the joint surface to its anatomic location.

### Technique of Glenohumeral Arthroplasty

Glenohumeral arthroplasty provides the surgeon with the opportunity to use all the principles related to the restoration of motion, strength, stability, and smoothness. All adhesions and contractures must be released, and the smoothness of the non-articular humeroscapular motion interface must be reestablished. Obligate translation is avoided by appropriate capsular releases.

FIGURE 5-39.

A, Ideally, the humeral component provides a maximal articular surface area. B, Significant portions of the intraarticular space can be consumed by non-articular aspects of a modular prosthesis.



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Strength is optimized by placing the muscle-tendon units under proper tension. Stability is achieved by normalizing joint surface orientation and providing the appropriate geometry for the concavity compression stabilization and balance mechanisms. Smoothness is provided by the prosthetic joint surfaces and by immediate postoperative motion.

### Surgical Approach

After a brachial plexus block or general anesthetic, the patient is placed in the beach chair position with the thorax up at an angle of 30 degrees. The shoulder is just off the edge of the operating table so it can be moved freely through an entire range of motion. The anesthesiologist is positioned at the side of the neck on the opposite side from the shoulder being operated on. A careful double skin preparation includes the entire arm and forequarter, anteriorly and posteriorly. Draping allows access to the entire scapula, clavicle, and humerus.

**Skin Incision.** This is made over the deltopectoral groove along a line connecting the midpoint of the clavicle to the midpoint of the lateral humerus and crossing over the coracoid process (Fig. 5-40). This incision avoids the axilla, protects the neurovascular supply to the deltoid, and provides direct access to the deltopectoral interval without requiring skin flaps. Gelpi retractors placed in the subcutaneous tissue help provide hemostasis as the incision is carried to the level of the deltopectoral fascia. The deltopectoral interval is developed medial to the cephalic vein, preserving its major tributaries from the deltoid muscle. Incising the clavipectoral fascia at the lateral edge of the conjoint tendon up to, but not through, the coracoacromial ligament provides entry to the non-articular humeroscapular motion interface. The axillary nerve is identified as it courses across the inferior border of the subscapularis.

The subscapularis is the one tendon incised in performing a glenohumeral arthroplasty. Restoring the excursion of this ten-

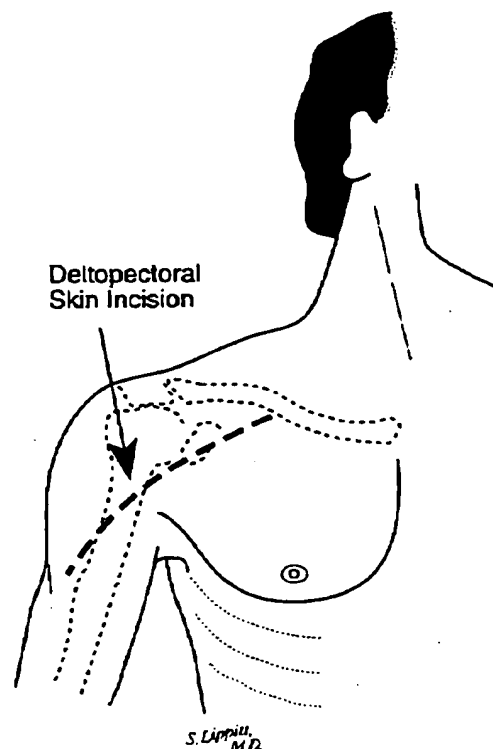
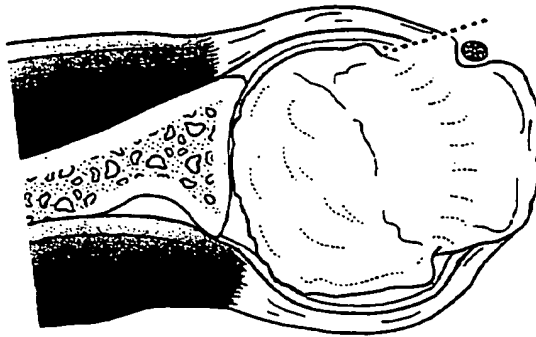


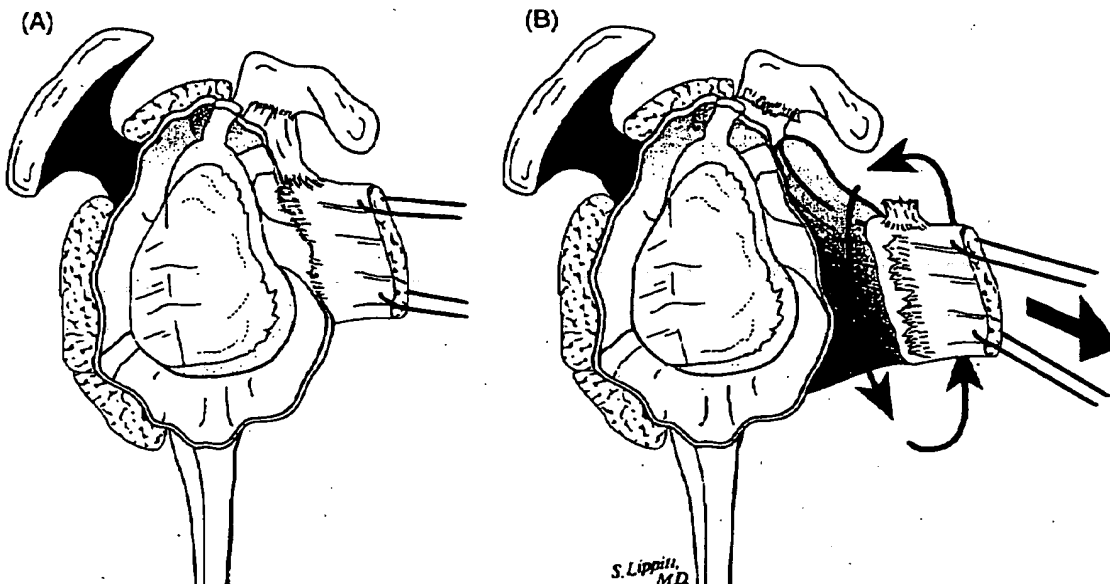
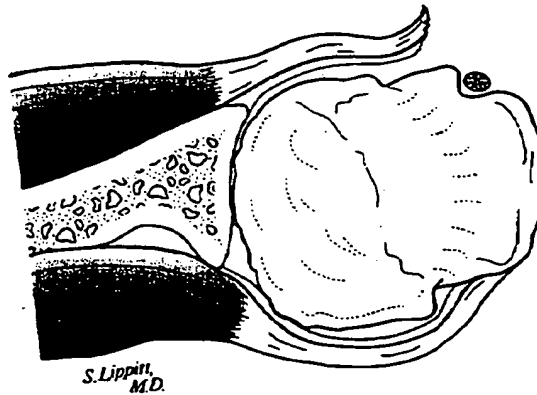
FIGURE 5-40.

Anterior deltopectoral skin incision extending along a line from the midpoint of the clavicle to the midpoint of the lateral humerus (deltoid tubercle). Note that this line of incision crosses the coracoid tip.

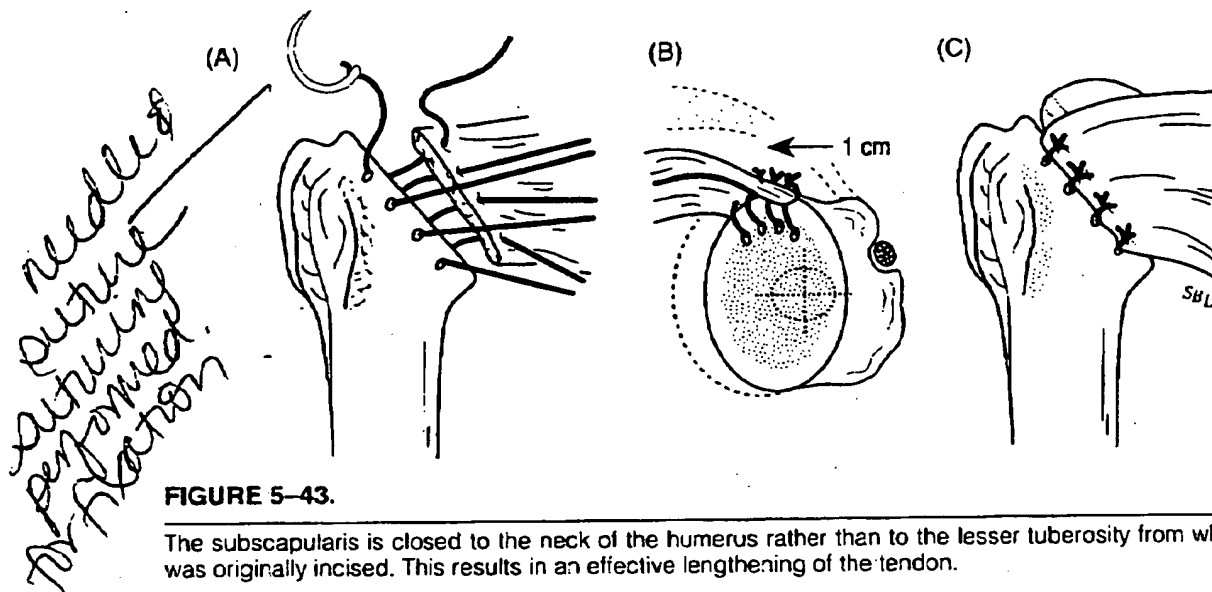
don as well as its firm reattachment to the humerus is critical to the restoration of the range, stability, and strength of the shoulder. Our routine is to incise the subscapularis tendon as close to the bicipital groove as possible to gain maximal length of quality tendon; no subscapularis tendon is left on the lesser tuberosity. The anterior glenohumeral capsule is incised from its attachment to the glenoid and is left attached to the deep surface of the tendon to reinforce it (Fig. 5-41). A 360 degree release of the subscapularis tendon is then performed (Fig. 5-42), ensuring that it moves freely with respect to the glenoid, the coracoid, the coracoid muscles, the axillary nerve, and the inferior capsule. Additional subscapularis length is gained at the time of closure by reattaching it with sutures placed in the anterior humeral neck rather than the lesser

**FIGURE 5-41.**

The subscapularis incision. The subscapularis and the subjacent capsule are incised directly from the lesser tuberosity, striving for maximal length of the tendon.

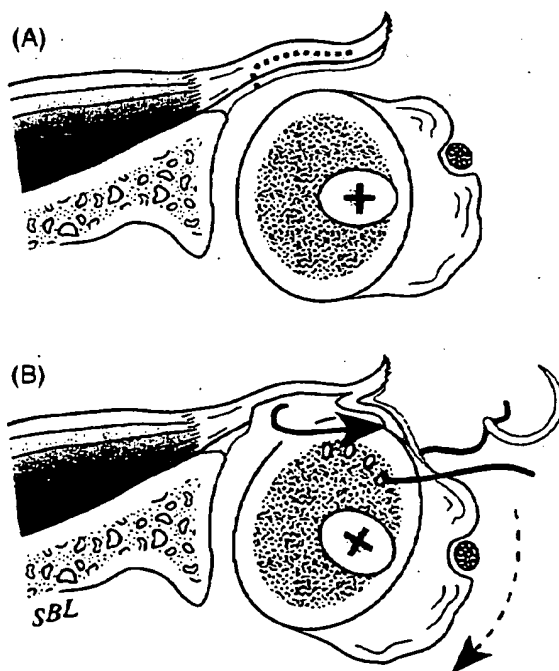
**FIGURE 5-42.**

Mobilization of the subscapularis tendon. A, Attachment of the subscapularis tendon and capsule to the coracoid and glenoid. B, A complete 360-degree release about the subscapularis tendon optimizes muscular excursion and functionally increases the length of the subscapularis.



tuberosity (Fig. 5-43). If still more length is needed, an inside-out coronal plane Z-plasty can be performed, using the capsule to extend the tendon (Fig. 5-44). Each centimeter of subscapularis lengthening provides approximately 20 degrees of increased external rotation.

The capsule remaining on the anterior glenoid is excised along with any residual labrum. With a finger protecting the axillary nerve, the inferior capsule is incised from the glenoid, exposing the origin of the long head of the triceps (Fig. 5-45). Occasionally, if triceps contracture impedes motion, the



**FIGURE 5-44.**

The inside-out Z-plasty. A, Additional length of the subscapularis tendon can be gained by splitting the capsule from the tendon medially, leaving their connection laterally. B, The medial end of the split capsule is reflected and attached to the humeral neck.

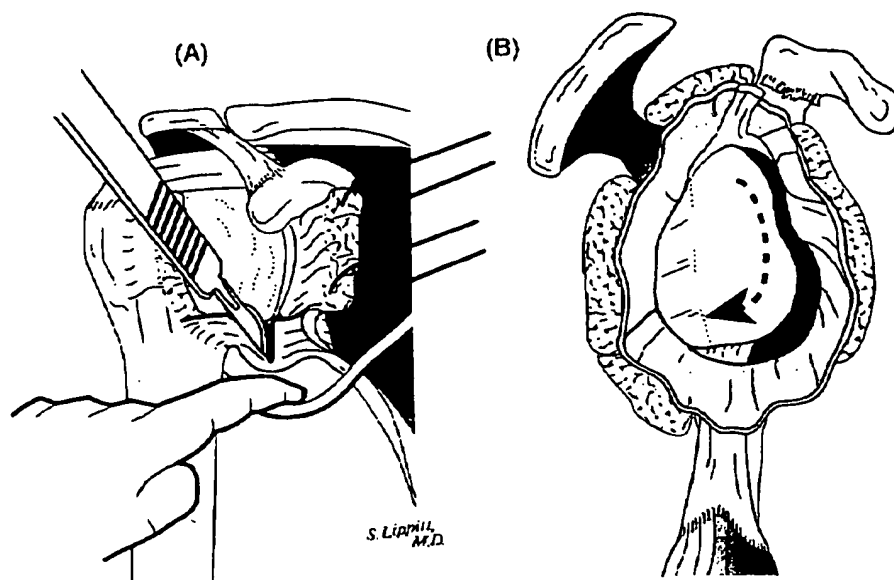


FIGURE 5-45.

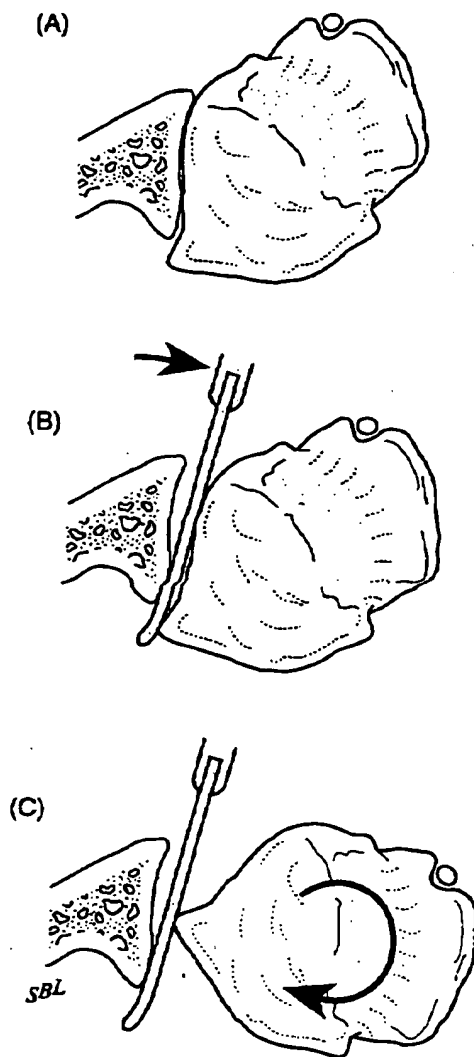
A, Division of the anteroinferior capsular attachments to the glenoid under direct vision while axillary nerve is protected and retracted. B, Capsular release to the 6 o'clock position on the glenoid exposes the origin of the long head of the triceps, which may require release as well.

triceps origin may need to be released in a manner similar to the adductor release in hip arthroplasty. If the posterior capsule is tight, it can be released later under direct vision after the humeral head has been excised. Posterior capsular release should not be performed if there is preoperative evidence of posterior subluxation.

**Humeral Preparation.** The humeral head is dislocated anteriorly by *gentle* external rotation and slight extension of the arm. Special care is exercised in elderly patients and in those with rheumatoid arthritis or other causes of fragile bone. Any resistance to this maneuver indicates the need for additional soft tissue release. Posterior humeral head osteophytes can impede the dislocation maneuver by impinging on the glenoid as the humerus is externally rotated. This phenomenon is suggested if the glenohumeral joint opens anteriorly like a book as the humerus is externally rotated. Often, in this situation, the humeral head along with the osteophytes can be safely and gently lifted into the joint with a flat elevator used as a "shoe

horn," inserted while the humerus is internally rotated (Fig. 5-46). A malunited greater tuberosity or large osteophytes may require osteotomy. By incorporating the movements of external rotation, anterior subluxation, and extension of the arm, the articular surface of the humerus is brought into view.

The humeral osteotomy requires attention to detail. In degenerative joint disease, the apparent articular surface does not provide an accurate indication of the plane of humeral head resection. Failure to account for the apparent elongation of the articular surface by inferior osteophytes results in an inordinately vertical (varus) resection level (Fig. 5-47). An excessively inferior or retroverted plane of resection jeopardizes the greater tuberosity and the insertion of the rotator cuff. To avoid these pitfalls, the humeral cut is based on readily identifiable landmarks. The ideal cut plane passes just inside the supraspinatus insertion to the tuberosity, at an angle of 45 degrees with the long axis of the shaft, and in 35 degrees of retroversion as judged by the external rota-

**FIGURE 5-46.**

Large posterior humeral osteophytes can form a barrier to external rotation and dislocation of the humeral head at arthroplasty surgery (A). Reduction of large posterior osteophytes onto the glenoid face can usually be accomplished by placing a smooth retractor through the joint while the humerus is in internal rotation (B) and then gently externally rotating the humerus (C).

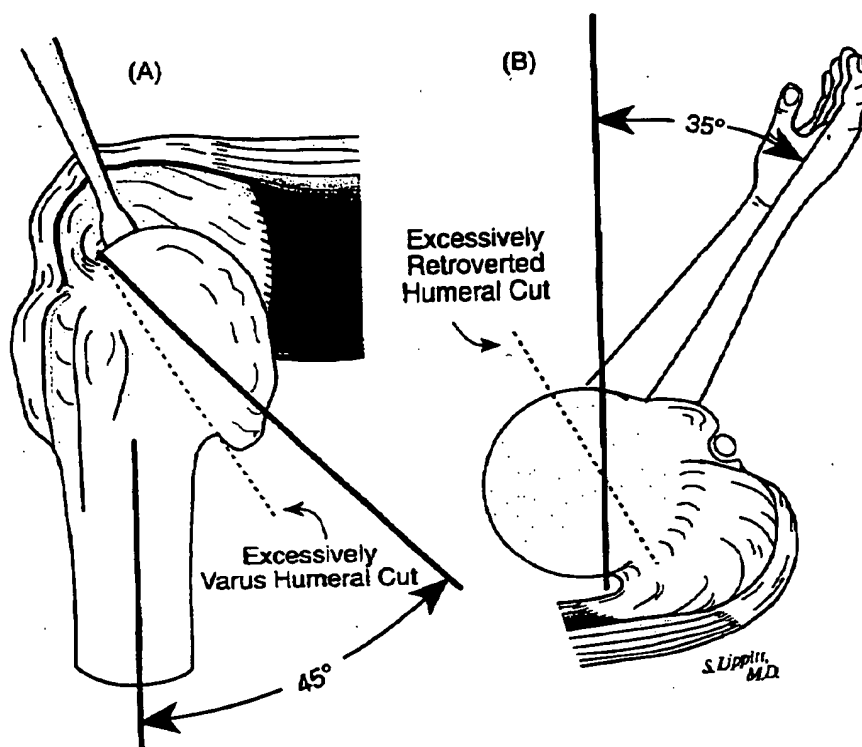


FIGURE 5-47.

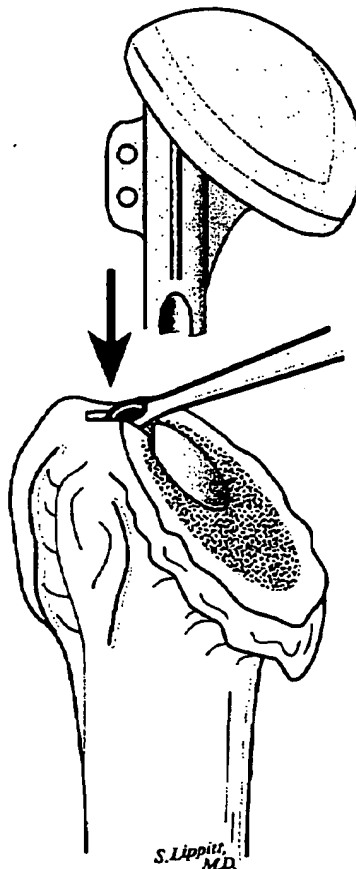
Humeral osteotomy planes. A, The preferred osteotomy plane passes just inside the insertion of the rotator cuff to the greater tuberosity and proceeds at a 45-degree angle with respect to the long axis of the humeral shaft. If the osteotomy is incorrectly oriented such that it emerges at the margin of the osteophytes (dotted line), the resulting cut will be in excessive varus. B, Humeral osteotomy also requires careful attention to version. An excessively retroverted cut (dotted line) compromises the cuff insertion.

tion of the forearm with the elbow flexed to a right angle. Cutting the head under direct vision with an osteotome while protecting the cuff with a blunt elevator facilitates verification of the plane and safety of the cut. Throughout the osteotomy, the cuff insertions and the biceps tendon are protected and observed as the osteotome passes by.

At this point the surgeon has an opportunity to judge the laxity of the joint. By placing the arm in 45 degrees of elevation and by using a finger to push the humeral neck laterally, the surgeon can get an idea of the joint volume remaining for the glenoid and humeral head component. This step is helpful in determining the need for further soft tissue balancing. If the capsule is so tight that even the smallest head will not fit, more release is required. Cutting away more neck

is not an option because the humeral cut is already at the cuff insertion.

The medullary canal of the humerus is reamed, starting at a point lateral on the cut surface just behind the bicipital groove. Starting with a small-diameter reamer, reaming is continued up to the diameter appropriate to the component, using a slight valgus bias and while protecting the biceps and cuff. Slots are made in the tuberosity to accommodate the fins of the component. The slot for the lateral fin should be just posterior to the bicipital groove (Fig. 5-48). In the presence of dense bone, failure to achieve adequate depth of these slots may result in the component being pushed into a varus orientation by contact between the fin and the bone of tuberosity. A trial component body is inserted so that the prosthetic neck

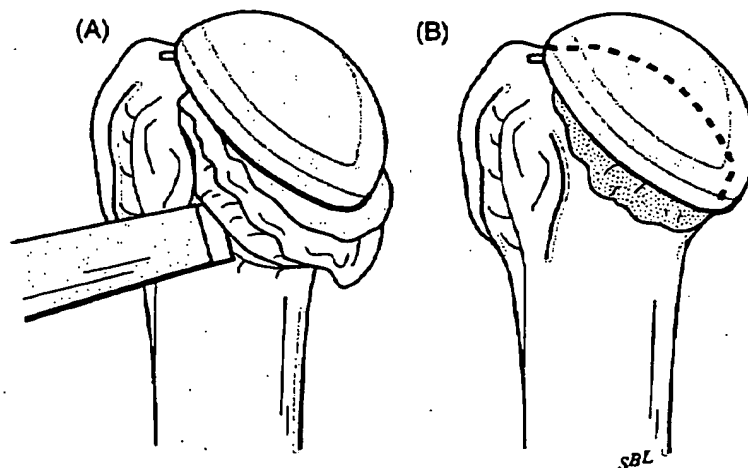
**FIGURE 5-48.**

Before implantation of the trial component, a slot is curetted in the tuberosity just posterior to the bicipital groove to accommodate the fin of the trial component.

is centered on the neck of the bony humerus, being neither too high (where the component will lead to excessive tension on the superior cuff), nor too low (where it will lead to subacromial abrasion of the tendons on elevation of the arm). The trial component is used as a guide to the excision of the osteophytes all around the humeral head (Fig. 5-49). The rotator cuff, axillary nerve, and glenoid are protected during osteophyte excision.

While the trial humeral head is in place, the surgeon can verify that there is sufficient subscapularis length to allow 40 degrees of external rotation and adequate posterior stability as indicated by 70 degrees of internal rotation of the arm elevated to 90 degrees in the coronal plane ("scarecrow" position) and 15 mm of translation on the posterior drawer test. If the joint is too tight with the trial head component alone, it will be tighter after the glenoid is inserted. If necessary, additional capsular releases are formed at this stage to achieve the desired laxity. Additional posterior capsular release may be accomplished by incising the capsule at the glenoid rim while the capsule is held in tension by a proximal humerus tractor (Fig. 5-50). Care is taken to protect the axillary nerve below and the cuff behind.

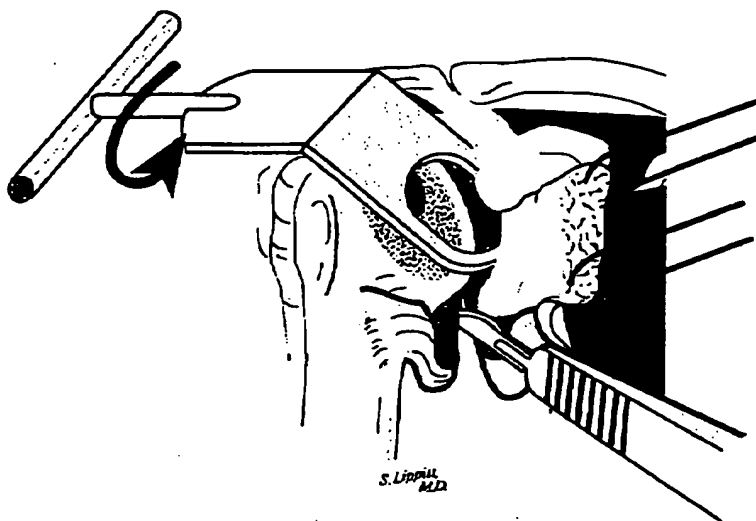
With the trial humeral component moved and the proximal humerus displaced medially into the joint, the rotator cuff

**FIGURE 5-49.**

A, Trial prosthetic humeral head seated against bone where it can serve as a guide for resecting any anterior, and posterior osteophytes that extend beyond the extrapolated articular surface. B, Osteophytes resected. The anterior, inferior, and posterior humeral neck. Posterior osteophytes must be removed with great care to protect rotator cuff insertion.

**FIGURE 5-50.**

If necessary, the sequential posterior release is accomplished by incising the capsule at the glenoid rim (release at the humerus would jeopardize the cuff insertion). During this release, the capsule is tensed by twisting the humeral retractor. Care is taken to protect the axillary nerve below and the cuff behind.

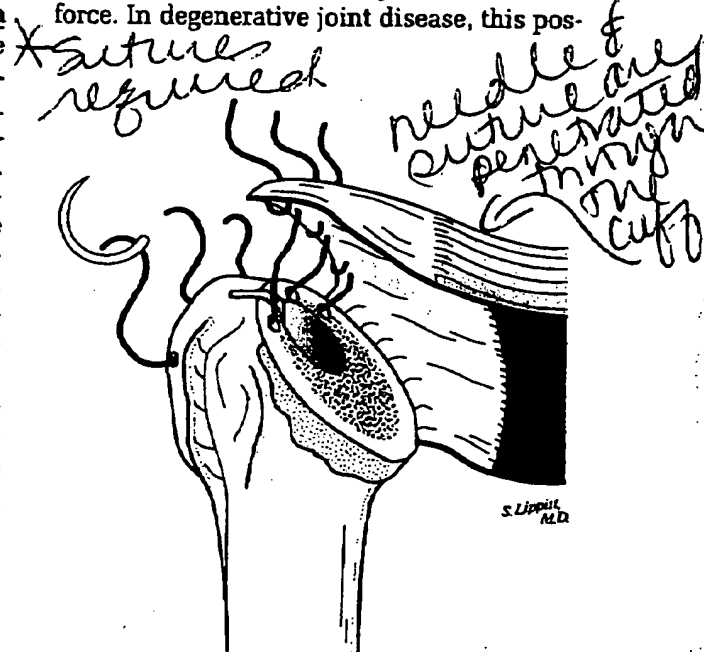


palpated to establish its integrity. If a repairable defect involving quality cuff tissue is identified, the retracted tendon is mobilized so it can reach the tuberosity without undue tension with the arthroplasty components in place. Sutures are placed in the edges of torn cuff tendon and through drill holes in the tuberosities for later tying after the components have been implanted (Fig. 5-51). Shorter humeral head components may facilitate cuff repair without undue tension. Cuff repair in association with shoulder arthroplasty tightens the joint and slows the rehabilitation. Thus, the surgeon must ensure that the repair is strong and durable. Suturing of poor-quality tendon or attempting repairs when insufficient tissue is present is not advised.

Tuberosity non-unions should be identified and mobilized at this point. Severe tuberosity malunions should be osteotomized; however, this should not be performed lightly: gaining tuberosity union can be difficult in the presence of a metal humeral component, diminished bone stock, and soft tissue contractions.

**Preparation of the Glenoid.** Accurate preparation of the glenoid bone requires the excellent surgical exposure provided after humeral head and osteophyte excision and capsular release. A flat retractor is placed behind the posterior glenoid lip to push the

head of the humerus posteriorly. When the resected surface of the humeral neck is flat against the back of the retractor (the arm externally rotated 35 degrees), the humerus can be pushed posteriorly with minimal force. In degenerative joint disease, this pos-

**FIGURE 5-51.**

Repair of a rotator cuff tear. If tissue is adequate for repair, drill holes are placed in the tuberosities for cuff attachment before the insertion of the humeral component.

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terior displacement of the humerus is often facilitated by the fact that the humeral head has been chronically subluxated in the posterior direction. Initially, the glenoid exposure in degenerative joint disease may appear to be poor because the eroded glenoid appears to face excessively posteriorly. The exposure is often better than it initially seems, however, because the preparation of the glenoid surface will be along the normalized glenoid center line.

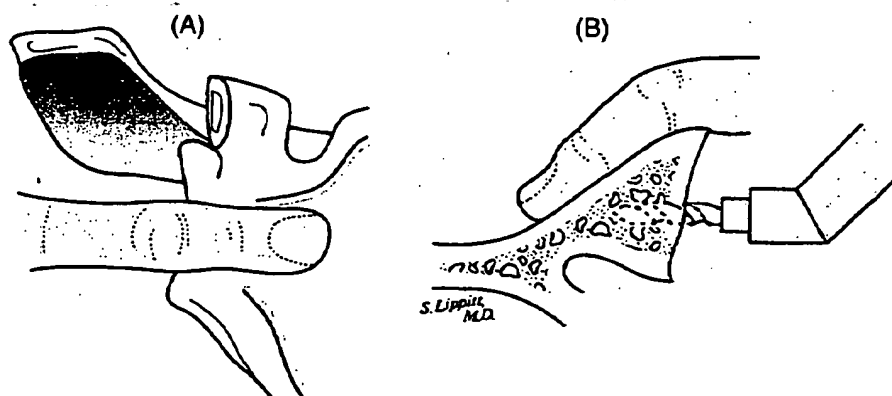
The goals of the glenoid part of the arthroplasty are (1) normalized glenoid orientation, (2) direct support of the component by precisely contoured bone, (3) secure fixation, and (4) avoidance of overstuffing.

We define glenoid orientation in terms of the glenoid center line, that is, the line perpendicular to the center of the normally oriented glenoid face. The shoulder arthroplasty surgeon should practice verifying the landmarks for a normal glenoid center line by drilling holes perpendicular to the midpoint on the glenoid face of normal cadaver scapulae and observing their exit in a consistent spot just medial to the anterior scapular neck, that is, the centering point. This spot lies between the upper and lower crura of the body of the scapula as they approach the neck. After the capsular releases have been performed at surgery, this centering

point can be palpated at the lateral extent of the subscapularis fossa.

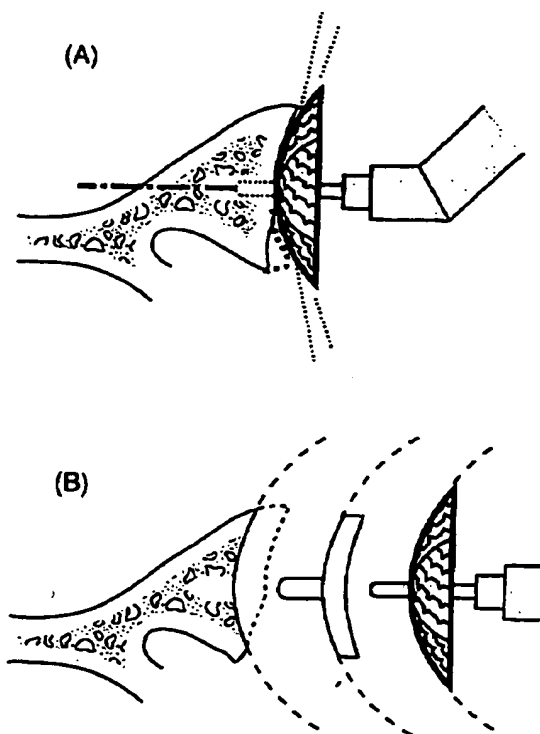
Because the location of this center point is unaffected by arthritis, it is of great value in normalizing the orientation of a distorted glenoid face. It is particularly useful in correcting the posterior facing of the glenoid face that commonly results from posterior erosion in degenerative joint disease.

An index finger identifies the center point on the anterior scapular neck (Fig. 52) while a hole is drilled from the center of the glenoid face toward it. Thus, the glenoid center line is defined from anatomic landmarks that are independent of the direction in which the pathologic glenoid appears to be facing. The orientation of the glenoid face is normalized using a spherical reamer with a guiding peg inserted along the glenoid center line drill hole (Fig. 5-53). In degenerative joint disease, this usually requires removal of more glenoid bone anteriorly than posteriorly because of the pathologic posterior erosion of the glenoid bone typical of this condition. During the reaming procedure, the amount of remaining bone support of the anterior glenoid margin can be monitored under direct vision to ensure that adequate bone stock remains to support the component. Ideally, reaming is continued until the entire bony glenoid face is spherical.



**FIGURE 5-52.**

Use of the glenoid centering point to help orient the hole for glenoid fixation. A, The index finger is inserted anterior to the glenoid so that its tip palpates the centering point in the sulcus bounded by the thick upper and lower crura of the scapula and the flare of the glenoid vault. B, This centering point serves as a useful guide for drilling along the normal glenoid center line, particularly when the anatomic structure is distorted by eccentric glenoid wear. The normal glenoid center line connects the center of the glenoid face with the centering point.

**FIGURE 5-53.**

A, Reaming along the drilled glenoid center line. The objective is to normalize the glenoid orientation and to contour the glenoid face to match the back of glenoid component. B, Accurate contouring of the glenoid face improves the quality of bony support for the glenoid component.

cally symmetric about the glenoid center line. Sufficient reaming is indicated if a smooth back trial glenoid slips easily around on the prepared surface while maintaining congruent contact with the prepared bone (the "Ivory Soap" sign). Rarely, if significant posterior bony support cannot be obtained without removing excessive anterior glenoid bone, a bone graft can be considered posteriorly (Fig. 5-54). In rheumatoid arthritis, minimal reaming is necessary and caution is needed—rheumatoid bone is soft and reams quickly.

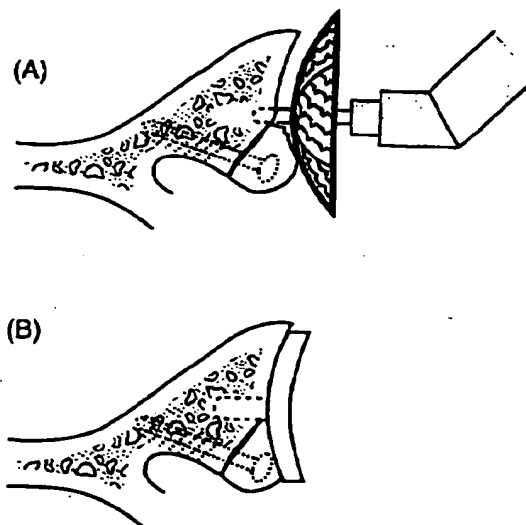
Once the reaming is completed, the glenoid center line hole can be used to orient precisely a drill guide for making additional fixation holes as required by the particular glenoid component design. Each hole is checked to determine if it is competent or if it extends through the bone.

Fixation \*

A glenoid component is selected that covers the prepared glenoid face with minimal overhang. A bigger component provides more stability and more component-to-bone load transfer. The quality of the glenoid bone preparation is checked by inserting the glenoid trial and ensuring that it does not rock even when the surgeon's finger applies an eccentric load to the rim.

After water spray irrigation, the holes can be cleaned and dried with a spray of sterile CO<sub>2</sub> gas. A small amount of cement is added to the holes, and the component pressed into position. If the back of the glenoid component matches the prepared bony face, there is no advantage in an interposed layer of cement, which could fail and displace, leaving the glenoid component relatively unsupported. Contact between precisely contoured bone and polyethylene provides an optimal load transfer mechanism. Fixation is checked, and the absence of residual cement bits in the posterior shoulder is verified.

In certain circumstances it may be advisa-

**FIGURE 5-54.**

Posterior glenoid bone grafting. When there is a major defect of the posterior glenoid, humeral head or iliac bone graft can be used to replace a deficient glenoid lip. If the fixation screw is recessed, the bone graft can be contoured and reamed for balanced support of glenoid component.

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ble not to insert a glenoid component in spite of major abnormalities of the glenoid articular surface. One is the condition known as cuff tear arthropathy, for which the surgical approach is described in some detail later. Other conditions in which a glenoid is not inserted include situations when there is insufficient bone to support the component or where there is insufficient room within the soft tissue envelope of the shoulder to accommodate even the thinnest prosthetic glenoid. Glenoid component replacement may be inadvisable after a previously failed glenoid replacement. In this situation, the bone of the glenoid vault is compromised, and the chances of obtaining durable fixation of another component are greatly reduced. Finally, when there is a previous history of infection that has been clinically silent for a number of years, performing a cementless humeral hemiarthroplasty without a glenoid component may be a less risky approach than a full glenohumeral arthroplasty. In these situations it may also be advisable to perform a non-prosthetic glenoidplasty. Here the glenoid bone is prepared exactly as described earlier, using the glenoid center line and a concentric reamer of a diameter slightly larger than the diameter of the humeral head component's articular surface. However, a prosthetic glenoid is not inserted. This approach provides the advantages of normalization of the glenoid orientation and concavity without the risk of implantation of a glenoid component.

**Insertion of the Humeral Body.** Prior to the insertion of the body, the surgeon places at least five sutures of No. 2 non-absorbable suture in secure bone at the anterior humeral neck for later attachment of the subscapularis tendon. In a modular arthroplasty, the humeral body alone is inserted into the prepared canal at this point. If the tuberosities are intact, and if a good canal fit is obtained, no cement is required. Otherwise, cement may offer needed control of rotation and component height. The prosthetic humeral body is inserted so that its neck is centered on the anatomic humeral neck and the articular surface is correctly oriented. Proper orientation of the humeral component is more difficult than is com-

monly realized. An excessively prominent humeral component overstuffs the joint, compromises its range of motion. An excessively high component tightens the soft tissues in abduction. An excessively low component leaves the tuberosities prominent where they may impinge on the undersurface of the acromion. A varus orientation places the component in an excessively medial position, tightening the joint by increasing the distance between the scapula and the tuberosities.

**Soft Tissue Balancing.** Balancing of the soft tissues must be completed before the definitive humeral component is inserted. Shoulder arthroplasty with balanced soft tissues should allow (1) 70 degrees of internal rotation of the arm elevated 90 degrees in the coronal plane, (2) 15 mm of posterior subluxation of the humeral head on the posterior drawer test, (3) 140 degrees of elevation, and (4) 40 degrees of external rotation of the unelevated arm with the subscapularis approximated. A tighter shoulder not only has limited range of motion but may also foster obligate translation at the extremes of motion with resultant rim loading, risking glenoid loosening and component deformation.

We have found the following strategies useful in optimizing soft tissue balance:

1. Adjust the posterior soft tissue tension with graduated posterior soft tissue releases as necessary.
2. If the posterior soft tissues are too tight in spite of complete capsular releases, use a component with a shorter head and neck.
3. If the posterior soft tissues are too loose, try a component with a longer head and neck.
4. If there is excessive posterior instability (more than 15 mm of posterior translation or complete posterior dislocation) that cannot be managed by increased head size, the shoulder should be inspected for the sectioning of the rotator cuff attachments during the humeral head osteotomy or for excessive retroversion of the glenoid component. If disruption of the cuff has occurred, cuff repair should be carried out before the humeral prosthesis

is fixed into position. Rarely, it may be necessary to tighten the posterior capsule by suture imbrication inside the joint prior to final humeral head component placement.

It is important to remember that with a humeral prosthesis that fits snugly in the medullary canal, changes in version of the component are not likely to have a major effect in adjusting soft tissue tension or stability.

The prosthetic articulation is observed for appropriate joint surface relationships and to ensure the absence of impingement of the medial neck and shaft of the humerus on the glenoid component. It also important to check for tuberosity abutment against the glenoid at the extremes of allowed motion. No part of the bony humerus should touch the glenoid component in any allowed position of the joint.

Prior to closure the wound is thoroughly inspected for debris. The joint is put through a full range of motion to verify smoothness and lack of unwanted contact. The wound is drained. The subscapularis is repaired securely to the humeral neck so that the elevated arm can be externally rotated by 40 degrees. If the subscapularis excessively limits the range of external rotation in spite of the 360 degree release of the tendon and the advancement from the lesser tuberosity to the neck, the inside-out Z-plasty is performed in which the capsule is used to lengthen the subscapularis tendon (see Fig. 5-44). The wound is closed in layers. Simple interrupted skin sutures are preferred when substantial drainage is anticipated or when wound healing may be impaired (such as in a patient receiving corticosteroids or with thin rheumatoid skin).

### ***Postoperative Care***

Because primary goals of arthroplasty surgery are to provide motion and smoothness, immediate postoperative passive motion is important. The immediate postoperative program is essentially the same as that used after the open release of a frozen shoulder. We use a simple motor-driven adjustable

cam and pulley system that puts the shoulder through a 90 degree arc of flexion and a 45 degree arc of rotation (see Fig. 2-38). This system is used for at least 24 of the first 48 postoperative hours. The patient is taught to use the opposite arm for assisted elevation and external rotation. A "motivation" chart is maintained on the wall of the patient's hospital room displaying progress toward the discharge goals of 140 degrees of elevation and 40 degrees of rotation (see Fig. 2-44). Grip and external rotation isometrics are started immediately. Unless a rotator cuff repair has been performed, the patient is encouraged to use the shoulder as comfort permits for active elevation and activities of daily living. If rotator cuff repairs or osteotomies have been performed, active motion and isometric cuff strengthening are delayed until healing has occurred.

The details of the standard program are shown in Patient Information 5-4.

### ***The Impact of Shoulder Arthroplasty on Shoulder Function in Degenerative Joint Disease***

Figure 5-55 shows the preoperative SST results for patients having glenohumeral arthroplasty for degenerative joint disease, as well as the SST responses from patients 6, 12, and 18 months after their surgical procedure. Such data not only indicate the increment of shoulder function but also reflect the time necessary to regain the various functions of the SST.

### ***Arthroplasty in Rheumatoid Arthritis***

The basic principles of shoulder arthroplasty in rheumatoid arthritis are similar to those in degenerative arthritis, but some important differences exist. Rheumatoid tissues are much more fragile. The bone is more prone to fracture, and the muscle and tendons are more prone to tear. Thus, from the outset, extreme care must be taken to preserve bone and soft tissue integrity. We

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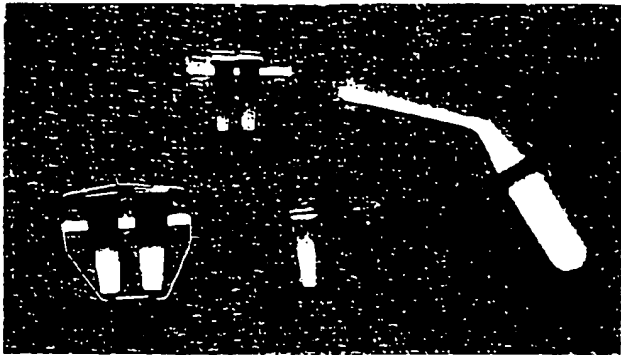


Figure 56-8. Variety of microclamps, both single and double, that may be used in microvascular surgery.

of the anastomosis (Figure 56-10) to avoid bunching the tissue near one spot of the anastomosis and to manage moderate-size discrepancies in lumen size. The surgeon can manage larger discrepancies in lumen size by an end-to-side technique, described later.

Acland has outlined the requirements to achieve a successful microanastomosis.<sup>3</sup> He deemphasizes the technical aspects of the microanastomosis itself and emphasizes that success is very dependent on attention to the essential preconditions of the microsurgery. He delineates these essential preconditions as (1) a good working environment, (2) good equipment, (3) operative planning, (4) comfortable position and hand support for the physician and his assistant under the microscope, (5) access and exposure in the surgical field, (6) proper choice of vessels, and (7) hemostasis. The technical aspects of a microanastomosis, or "central skills" as Acland refers to them, are of course extremely important. However, more failures of microvascular surgery are caused by the failure to attend to the delineated preconditions than to a lapse in the technical skills of suture placement.

I cannot overemphasize the importance of a proper work environment and the surgeon's comfort, both physical and mental, in the clinical microvascular situation. Many times a microvascular anastomosis is preceded by hours of tedious macrosurgery, coupled with an overriding desire to minimize the ischemia time of the transferred tissue. Both of these factors tend to hurry the technical aspects of the anastomosis and create a tense environment in the operating room. Such a situation argues for the team approach to microsurgery, where cooler and more rested heads can prevail in the surgical environment. A good microsurgical team consists of several experienced nurses who are familiar with the instruments and the logical sequence of events that take place in the microsurgical operating room. Acland appreciates the importance (and pleasure) of an environment in which each team member is valued. A surgeon who has spent hours debriding tissue or removing a tumor may prove his conscientiousness by calling for a rested team member

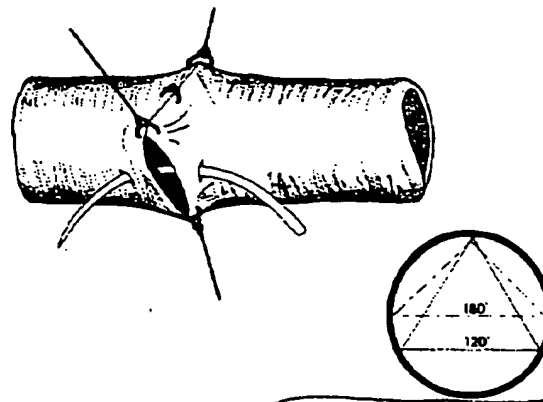


Figure 56-9. Placement of sutures 120 to 180 degrees apart (triangulation) and then placement of mild traction on those sutures facilitates placement of subsequent sutures with minimal chance of catching back wall. (Modified from Daniel RK and Terzis JK: Reconstructive microsurgery, Boston, 1977, Little, Brown & Co.)

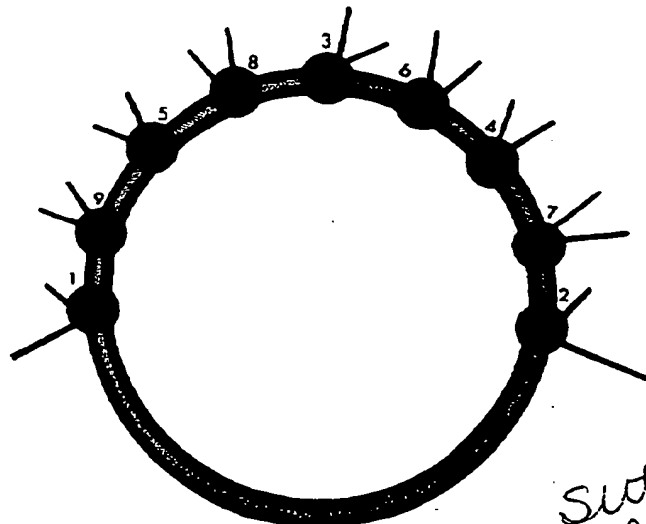


Figure 56-10. Example of placement of sutures bisecting space of two previously placed sutures. Numbers represent sequential placement of sutures. (Modified from Berge A and Tizian C: Atlas of microsurgical technique, Norfolk, Va, 1987, Hampton Press.)

Table 56-1. Recommended ratio of vessel size to suture size

Vessel size	Recommended suture size in diameter
>3 mm	8-0 (45 $\mu$ )
2-3 mm	9-0 (35 $\mu$ )
0.8-2 mm	10-0 (22 $\mu$ )
<0.8 mm	11-0 (18 $\mu$ )

From Shaw WW and Hidalgo DA Microsurgery in trauma, MT Kisco, NY, 1987, Futura Publishing Co., Inc.

## 1584 TECHNIQUES IN PLASTIC SURGERY



Figure 56-11. Comfortable sitting position with wrist resting on area adjacent to operative field. This ensures minimization of tremor and more accurate suture placement.

to come in and perform the technical exercise of the microvascular anastomoses.

Physiologic tremor is a normal involuntary motion accompanying all postures and movements.<sup>29</sup> Although it is usually less than a millimeter, physiologic tremor may lead to significant technical difficulties or frank errors in microvascular surgery.<sup>31</sup> Studies of physiologic tremor have determined that the tremor amplification is directly related to muscle tension.<sup>32</sup> Harwell and Ferguson<sup>33</sup> examined the causes of physiologic tremor and devised a biofeedback learning technique for diminishing this tremor.

Components of the motor system that maintain muscle tension and limb position are controlled by reflex spinal circuits.<sup>34</sup> These circuits contribute to the physiologic tremor. By resting the wrist comfortably on the operative field, the surgeon can physically block most of these recruited tremors (Figure 56-11). Instruments carried by the fingers must be lightweight to prevent mass loading of the fingers and must have low closing pressures to reduce the need for recruitment of large motor units. A relaxed body posture reduces tension in postural muscles and prevents coactivation of muscle in the hand and arm. The surgeon should avoid muscle fatigue from extensive surgery before the microanastomosis to prevent loss of smaller motor units critical to fine movements in the hand and fingers. Longer cases may require the team approach, with one team assigned to the majority of the macrosurgery and another team devoted to the microsurgery.

A low level of emotional stress is also very important in controlling tremor. A relaxed and calm approach to the microanastomosis will prevent excessive tremor, which Tyrer and Bond showed to be humorally mediated by epinephrine blood levels.<sup>35</sup> Indeed, propranolol was shown to be effective in reducing symptoms of anxiety in musicians

and in some cases improving their performance<sup>36</sup>; however, propranolol is not recommended for microvascular cases.

### Operative technique

**End-to-end anastomosis.** After the microsurgeon and the assistant get comfortably situated and the two ends of the blood vessels are placed next to each other without tension, the technical suturing of the microanastomosis begins.

Before placing the sutures, place a background behind the vessels to keep other tissue from impinging into the site of the anastomosis. Remove the adventitia from the ends of both vessels by blunt and sharp dissection with the microscissors. Irrigate the vessel lumens with a dilute solution of heparin (5000 units in 100 ml of saline) and remove any small clots carefully. Then examine the intima for any irregularities that might lead to thrombotic activity or turbulent flow. Do not tolerate damaged or loose intima. Trim the vessel in question further to a point where smooth, contiguous intima appear. Dilate the vessel slightly by placing a blunt vessel-dilating forceps into the lumen and spreading carefully. Overdilation can be dangerous and actually lead to spasm of the vessel. Slide the clamps holding the vessel ends on the connecting bar so that the vessels are approximately half a vessel's width from each other.

Pick up the needle and grasp it so that you angle the needle in the needle holder to place the needle in the tissue at a comfortable angle for the fingers and wrist. Grasp the tissue near the anastomosis with a tissue forceps, taking care not to grasp the intima. Place the needle perpendicular to the tissue and then pass it through the tissue. As the needle becomes visible in the lumen, rotate the needle to become parallel with the work surface. After several millimeters of needle are visible in the lumen, release the needle com-

→ suture passed through tissue

pletely, regrasp it, and pull it through the tissue gently at an angle consistent with the curve of the needle. *XX*

A tendency exists to attempt to pass the needle through both vessels in one stroke. This maneuver is unwise, especially for the novice; it allows for imprecision in placing the needle through the second vessel wall, which leads to tears or redundant flaps of vessel wall tissue. Withdraw the needle from the first vessel and then remount it on the needle holder to pass through the second vessel wall similarly.

After passing the needle through both sides, you may wish to switch to a lower magnification for a larger field of vision. This is helpful in seeing the suture wall to tie the knots properly.

Knot tying under the magnification of the operating microscope is actually quite easy and the experimental microsurgeon may tie the microsurgical knot faster than the macro-surgery knot. The main difference, as May<sup>50</sup> pointed out, is that microsurgical knot tying is a visual maneuver, and macro-surgical tying is a tactile maneuver.

To tie a knot grasp the suture to the left of the vessel lumen approximately 10 to 15 mm from the vessel edge and draw it to the center (Figure 56-12). This allows a loop to be formed. Pass the forceps through the loop and grasp the free end of the suture, which is approximately 3 to 4 mm long. Then pull the free end back through the loop till the suture knot is snug but does not tear the vessel wall (Figure 56-13). Use a surgeon's knot if slight tension exists at the anastomatic site. Complete the second throw of the square knot by making the loop in the opposite direction. To facilitate this you may use the needle holder to depress the suture in the direction you wish to make the loop, just as you begin the loop (Figure 56-14).

Complete a third and fourth throw in a fashion similar to throws one and two. The distance between the edge of the vessel and the suture should be equal on both sides and approximately 0.2 to 0.3 mm wide. The loose suture ends should be relatively short and should not stick into the lumen. If the knots have been tied correctly, the cut ends should lie perpendicular to the approximated edges of vessel and parallel to the line of placement of the suture. Alternatively, you may wrap a long end of the suture around the clamp in a figure-of-eight to hold the vessel in place and ready for second stitch placement (Figure 56-15).

Placement of the second suture is a very important step and will determine the placement of all other sutures in the anastomosis. Place the second suture from 180 to 150 degrees around the circumference from the other suture (Figure 56-16). Do this, of course, on both sides. This step is particularly critical if the lumen diameters are noticeably different. Place the suture at the same number of degrees on the second lumen to leave the same relative amount of circumference between the two sutures. After you accomplish this, the basic principle of bisecting the space between each suture is most likely to produce a patent anastomosis with optimal laminar flow.

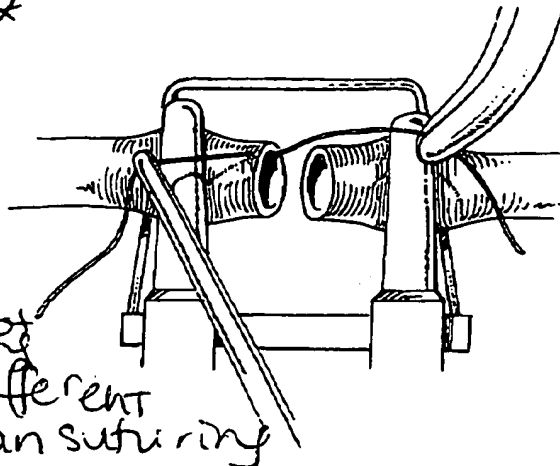


Figure 56-12. Suture is grasped and loop is formed by redundancy of suture.

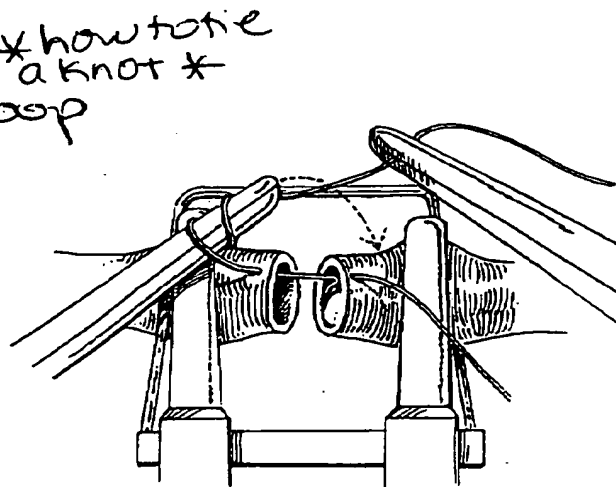


Figure 56-13. Free end of suture is then pulled through knot.

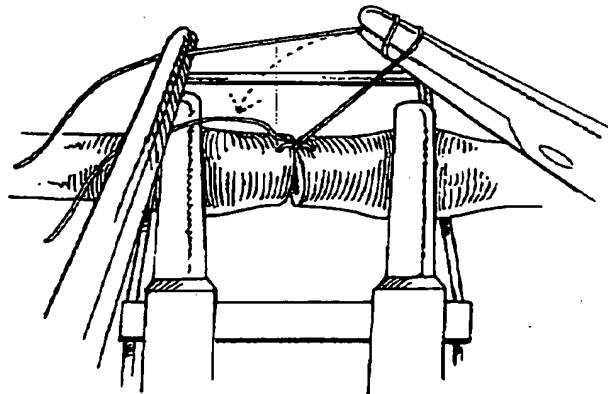


Figure 56-14. Second throw of knot is made square by making loop in opposite direction.

## 1586 TECHNIQUES IN PLASTIC SURGERY

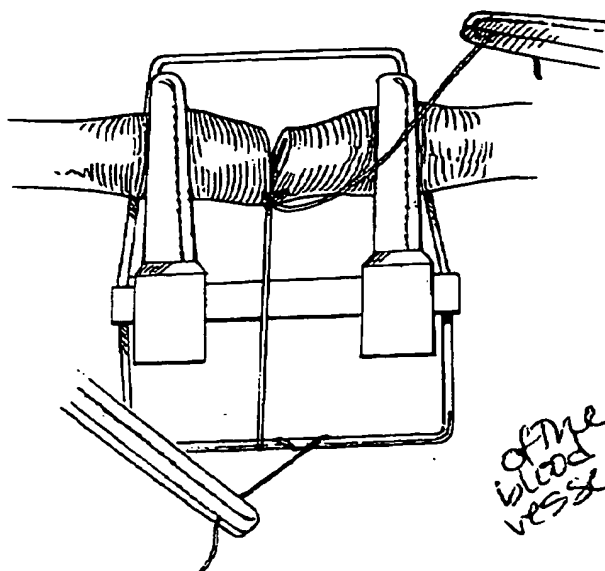


Figure 56-15. Slight tension is placed on this corner stitch, and short end is trimmed.

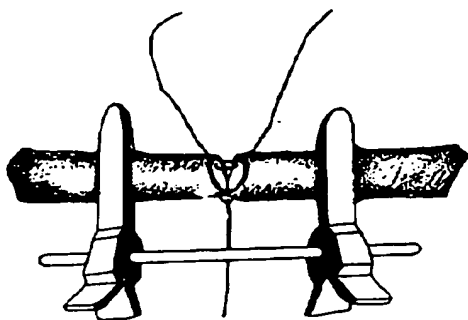


Figure 56-16. Second suture is placed 150 to 180 degrees from first suture. If vessels have size discrepancy, same number of degrees on each lumen should be approximated to prevent bunching of tissue.

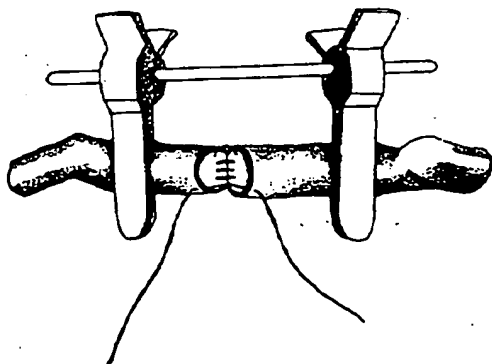


Figure 56-17. After completion of anterior wall, clamp is flipped over, which maintains vessel orientation and allows for completion of posterior wall in anastomosis.

As mentioned earlier, the triangulation technique is often used in placing sutures. This technique allows for precise placement of each suture at an exact distance from the sutures at the apices of the triangles. It also helps to pull the wall of the vessel away from the opposing wall and prevent placing the needle and suture through the back wall, thereby preventing occlusion of the lumen.

After completing the anterior wall, turn the vessels over 180 degrees and make a similar placement of the sutures with bisection of the distance between sutures on either side (Figure 56-17). Note the accuracy of placement of the front wall sutures in the lumen, and observe for an intimal flap or an inadvertent suture placement into the back wall. The last few sutures are more critical because the lumen of the anastomosis is difficult to visualize and thus more danger exists of catching the back wall with the needle. To prevent this, place the last two or three sutures while observing the lumen and leave the sutures long. Then tie these last sutures sequentially just before microclamp release.

Consider anastomosing the artery or vein first, depending on the efficiency of the technical aspects. Take care that the artery does not cross over the vein before performing these anastomoses so that the vein is not partially occluded. With prolonged ischemia you may elect to complete the arterial microanastomosis and reestablish flow to the tissue before anastomosing the vein.

**End-to-side anastomosis.** Often an unacceptable discrepancy in size between a small flap vessel and a larger recipient vessel exists. A discrepancy greater than 2:1 will lead to excessive turbulent flow and intimal flaps that are unacceptably thrombogenic. Also, occasionally a vital single artery is present and cannot be sacrificed. An end-to-side anastomosis in this case will allow for flow to the flap as well as continued flow distally in the vital vessel.

Several experienced groups of microsurgeons have expressed a preference for the end-to-side anastomosis for two reasons. First, a cut end of a vessel will contract as the muscular layers of the vessel spasm. An arteriotomy in the side of an artery will actually be pulled wider as the muscular layer spasms because of the direction of the muscle fibers (Figure 56-18). This argues for the end-to-side anastomosis in cases of moderate or severe vasospasm. Second, because of the technique of the end-to-side anastomosis, it is less likely to catch the opposite vessel wall of the anastomosis.

To perform the end-to-side anastomosis, remove the adventitia from a small area. Grasp the muscular layer with a jeweler's forceps, pull, and cut it with a sharp scissors to obtain an oval opening. Surgeons often perform on the posterior wall of the end-to-side anastomosis first for technical ease. If they perform on the anterior wall first, the posterior walls are very difficult to visualize and technical errors are more likely. Consider cutting the donor artery at a slightly oblique angle to lessen the amount of turbulent flow (Figure 56-19).

In approximating the tissue the surgeon must decide how

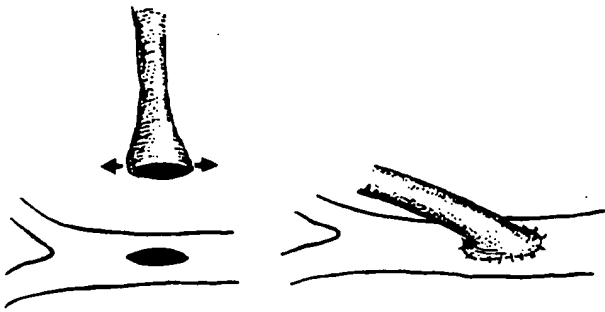


Figure 56-18. Although circular fibers of end-cut vessel will tend to narrow lumen, side cut in recipient vessel will become larger with smooth muscle contraction and tend to open lumen. (Modified from Daniel RK and Terzis JK: *Reconstructive microsurgery*, Boston, 1977, Little, Brown & Co.)

many sutures to use. If he uses too few, excessive leakage will lead to perianastomotic hematoma and eventual thrombosis within the lumen. If the surgeon places sutures too close to each other, they may constrict the lumen diameter and also expose an undue amount of subintimal thrombogenic substances, causing excessive white thrombus formation and perhaps blockage of the lumen. Colen and co-workers<sup>17</sup> studied this problem in a rat femoral artery model and found that eight sutures were the ideal number for strength of the anastomosis and for patency. However, the surgeon rarely encounters the exact diameter of the rat's femoral artery without a lumen size discrepancy in the clinical situation. The number of sutures should be enough to obtain a good seal within 2 to 3 minutes of reestablishing flow. A microamount of white thrombus formation to plug the gaps between sutures is helpful to prevent excessive leakage and hematoma.

Continuous suture technique is not well accepted in microvascular surgery, and the objectives of lumen narrowing and purse-stringing are exacerbated in the microvascular arena. The main advantage is a marked reduction in anastomotic time (often greater than 50%). Hamilton and O'Brien<sup>30</sup> believe that the time advantage is outweighed by other technical problems. Acland and Man<sup>5</sup> described a modified continuous suture technique equal in patency rate to the interrupted suture technique. Continuous suture technique is less constricting in the case of the end-to-side anastomosis. Especially in larger microvessels, running the suture down one wall and running a second continuous suture on the other wall is frequently possible.

**Vein grafts.** Not infrequently the distance between the recipient vessels and the free flap vessels is too great to allow for direct anastomosis of the vessels. This is particularly a problem in severe trauma to the lower extremities, where the microsurgeon must perform the anastomoses outside of the zone of injury. Tension on the microanastomosis

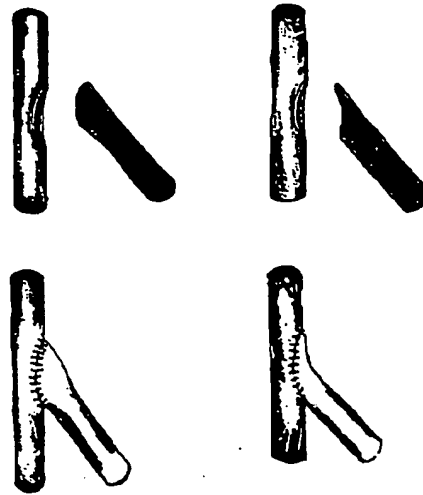


Figure 56-19. Proper trimming of donor vessel in convex form allows for adequate lumen formation (*below*). Concave formation of vessel tends to block lumen with anastomosis (*above*). (Modified from Shaw WW and Hidalgo DA: *Microsurgery in trauma*, Mount Kisco, NY, 1987, Futura Publishing Co., Inc.)

is absolutely unacceptable and will inevitably lead to thrombosis. The surgeon in this situation should use autologous vein grafts to bridge the gap.

The size and length appropriate for vein grafting can be found in the forearm, metacarpal region, or leg. For lower extremity trauma, use the opposite leg or an arm as a donor, since the severe trauma may already have compromised the venous return in the affected leg. Consider these technical factors when choosing the vein graft: (1) the graft must be a similar size; (2) the length must be correct (a redundant vein graft will lead to kinking and turbulence); and (3) the direction of the valves must allow for proper flow.

For longer interposition vein grafts, construct a temporary arteriovenous shunt by anastomosing one end of the vein graft to the recipient artery and the other end to the recipient vein. This shunt allows for early established flow in the vein graft to check for patency and adequate flow in two of the microanastomoses. Make the attachment to the free flap by dividing the vein graft loop in the middle and completing the microanastomoses to the free flap vessels.

Investigators have not demonstrated vein graft length to be a factor in patency rates. However, avoid longer vein grafts of small diameter. Use gentle dissection of the vein. Generally perform the entire dissection by handling the tissues adjacent to the vein itself. Carefully ligate side branches. Too short a side branch will promote turbulent flow and thrombosis. Coagulate smaller side branches with a bipolar cautery. After harvesting the vein temporarily, store it in a physiologic solution (such as Ringer's lactate) to prevent dessication or mechanical injury.

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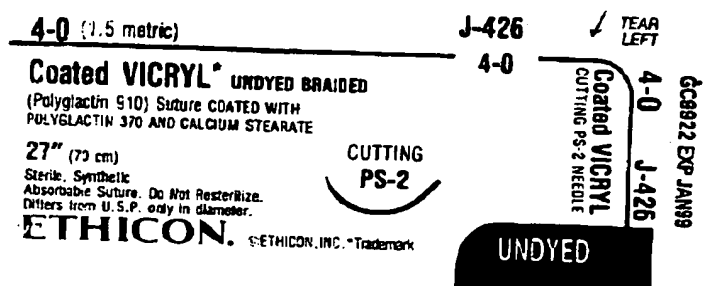
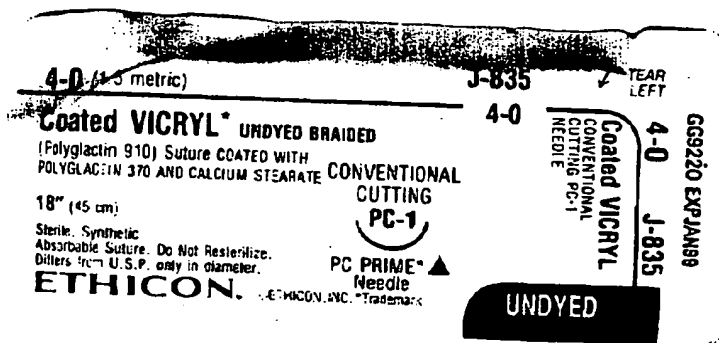
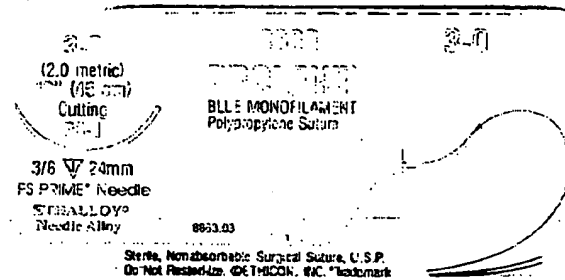
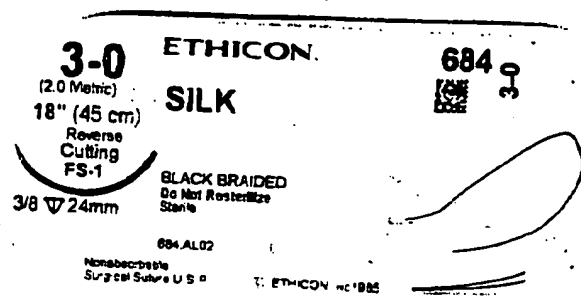
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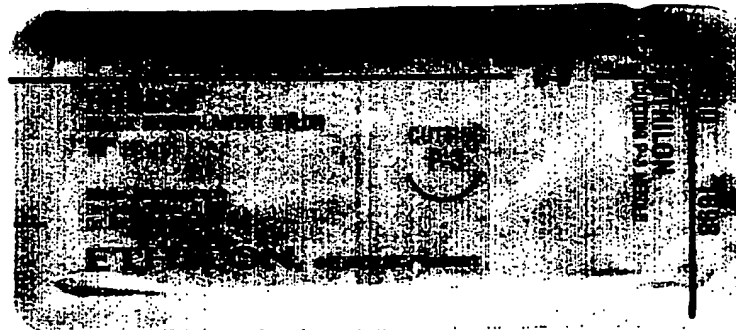
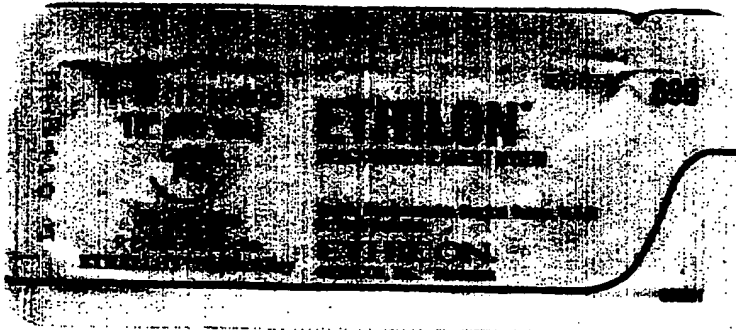
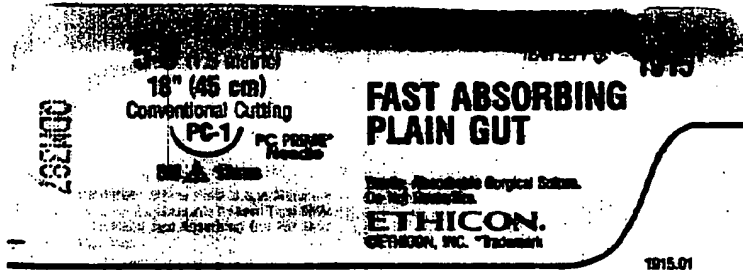


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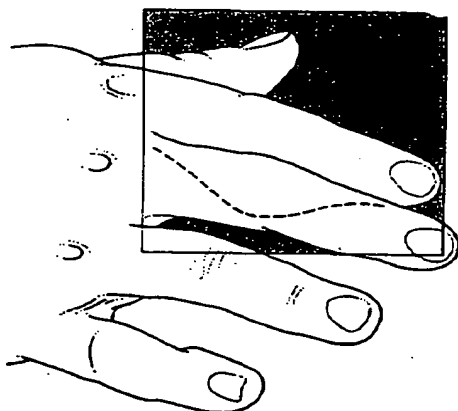
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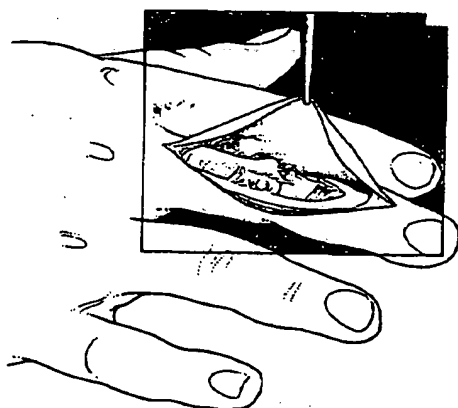
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Boutonniere deformities of the PIP joint are common athletic injuries that can present as acute instability with inability to extend the PIP joint. They may also present in a more insidious fashion with a note of a progressive deformity of PIP joint flexion and hypertension of the DIP joint. These injuries may be treated by splinting and passive flexion of the DIP joint, but frequently do not resolve with splinting alone, and require further surgical intervention.

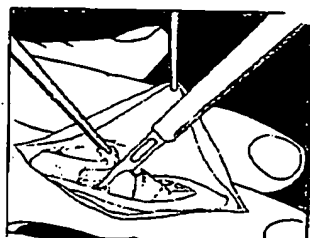
Surgical exploration usually reveals that the central slip is avulsed from the dorsal base of the middle phalanx. This avulsion historically has been difficult to repair. The Mitek® Micro QuickAnchor® has been proven helpful in facilitating reinsertion of the central slip into the base of the middle phalanx.



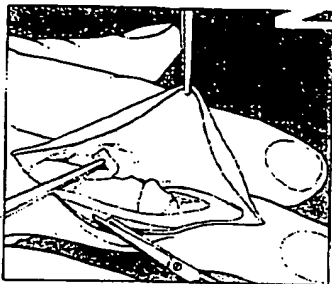
1. A curvilinear incision is made overlying the dorsal aspect of the PIP joint of the affected finger (Figure 1).



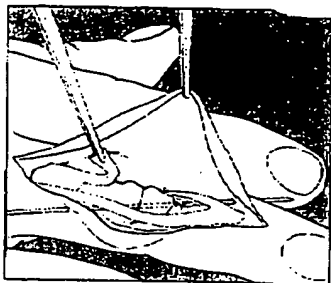
2. There is usually confluent scar formation overlying the PIP joint, with subluxation of the lateral bands volar to the mid-axis of the PIP joint and retraction of the normal tendinous portion of the central slip proximally from the PIP joint with splitting of the triangular ligament (Figure 2).



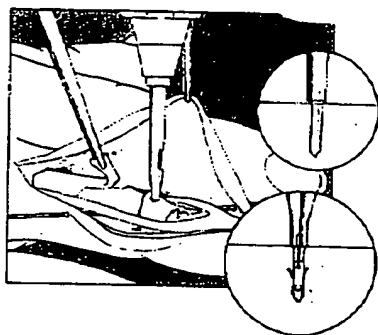
3. Incisions are made dorsal to the lateral band (Figure 3). The attenuated dorsal capsular structures are released from the base of the middle phalanx and retracted proximally until observation of the volar surface of the extensor tendon reveals tendon that appears normal. The scarred portion is excised in its entirety, and the central slip of the tendon is mobilized distally to the base of the middle phalanx.



4. At this point the transverse retinacula ligaments must be released at the level of the PIP joint to allow dorsal displacement and realignment of the lateral bands overlying the PIP joint (Figure 4). Once these structures are mobilized, the dorsal base of the middle phalanx is rongeured superficially to reveal a bleeding bed of cancellous bone.

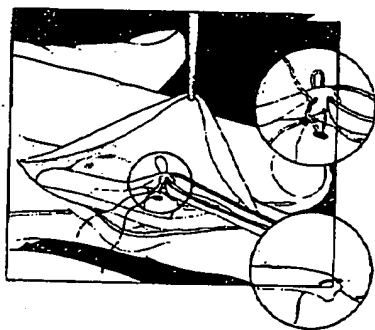


5. The PIP joint is pinned in extension in a retrograde fashion (Figure 5) with a .045 K-wire.



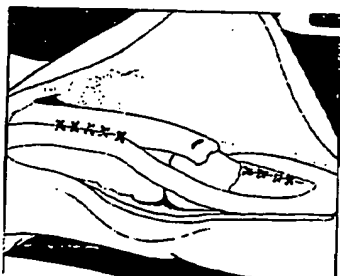
6. The drill hole for the Mitek® Micro QuickAnchor® is made dorsally at the base of the middle phalanx with the 1.3 mm drill bit supplied sterile with the anchor kit (Figure 6). A Mitek Micro QuickAnchor is inserted at the base of the middle phalanx according to the manufacturer's instructions, with care taken to ensure that the anchor is aligned with the drill hole axis. This will facilitate anchor deployment and proper subcortical insertion.

*through bone*



7. Once excellent fixation of the anchor is validated, the central slip is sutured to the middle phalanx in a fashion that permits the knot of the suture anchor to be buried beneath a portion of the tendon (Figure 7).

*suture penetrates central slip*

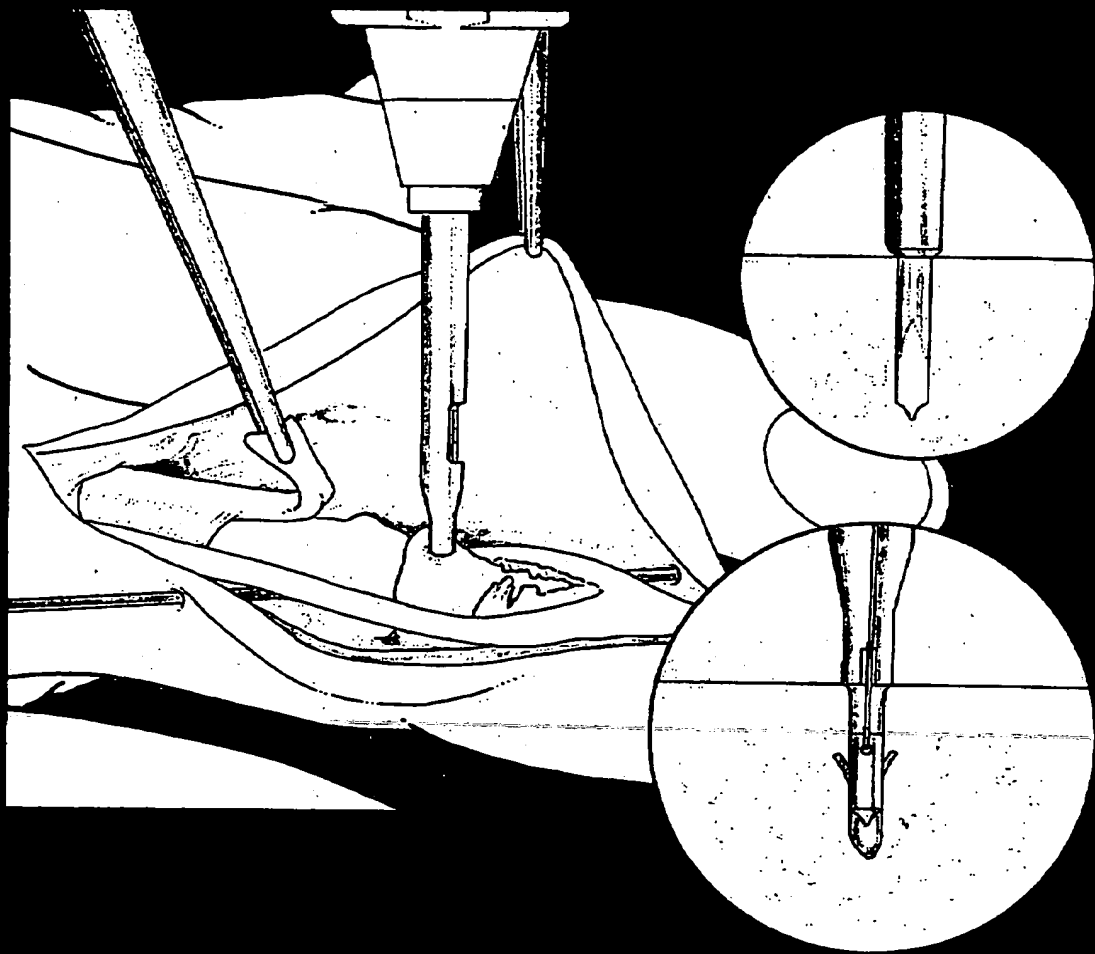


8. Once fixation of the central slip is completed, the lateral bands are brought dorsally to the level of the central slip and the triangular ligament is reapproximated with the 4-0 absorbable suture (Figure 8). When this is done, the wound is closed in layers and the patient is placed in a supportive splint that leaves the DIP joint free for passive flexion exercises.

The joint is protected in extension for 4 weeks at which time the transarticular pin is removed. The patient is maintained in a thermoplastic splint with PIP extension and DIP left free, and started on a very guarded actively assisted range-of-motion program that is continued 6 weeks after the surgery. Further

# MICRO ANCHOR

## SURGICAL TECHNIQUE MANUAL



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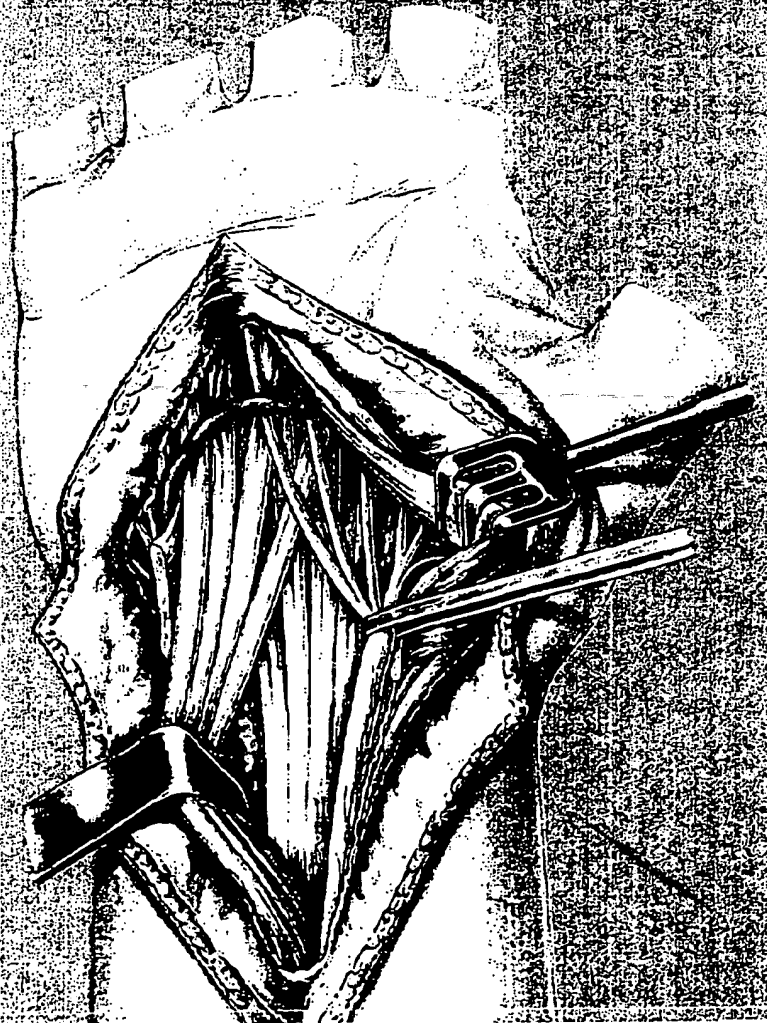
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# An Atlas of Surgical Exposures of the Upper Extremity

Paul Tubiana

Christopher J. McCullough

Alan C. Marsam



# An Atlas of Surgical Exposures of the Upper Extremity

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With illustrations by Léon Dorn

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# Shoulder

## Introduction

In this chapter, the anterior, superior, posterior and axillary approaches to the glenohumeral joint will be described, as will the anterior, transacromial and posterosuperior approaches to the subacromial space.

## Position of patient

For the anterior, superior and transacromial approaches to the shoulder, the patient should be placed in the semi-sitting or 'deck-chair' position. The head and neck are firmly supported on a head rest. The patient's trunk is raised at an angle of 40° to the horizontal. Elevation of the shoulder helps to reduce the bleeding during surgery. The legs must be slightly raised above waist level to prevent venous stasis. The arm is draped separately. A sandbag is placed under the medial border of the ipsilateral scapula. Access is thus afforded to all aspects of the shoulder. When simultaneous anterior and posterior approaches to the

shoulder are necessary, it may be more practical to put the patient in a seated position with the arm draped free. During the axillary approach, wide abduction of the arm is essential. For the posterior approach, the patient is placed prone with the head and neck firmly supported on a head rest (see page 57, A). The arm is draped separately.

## Skin incisions

Certain incisions placed over the anterior aspect of the shoulder heal poorly, often with keloid formation. Incisions should be placed parallel to the skin creases and should be closed with careful approximation of the subcutaneous tissues and a subcuticular suture to the skin.

*with ties.*

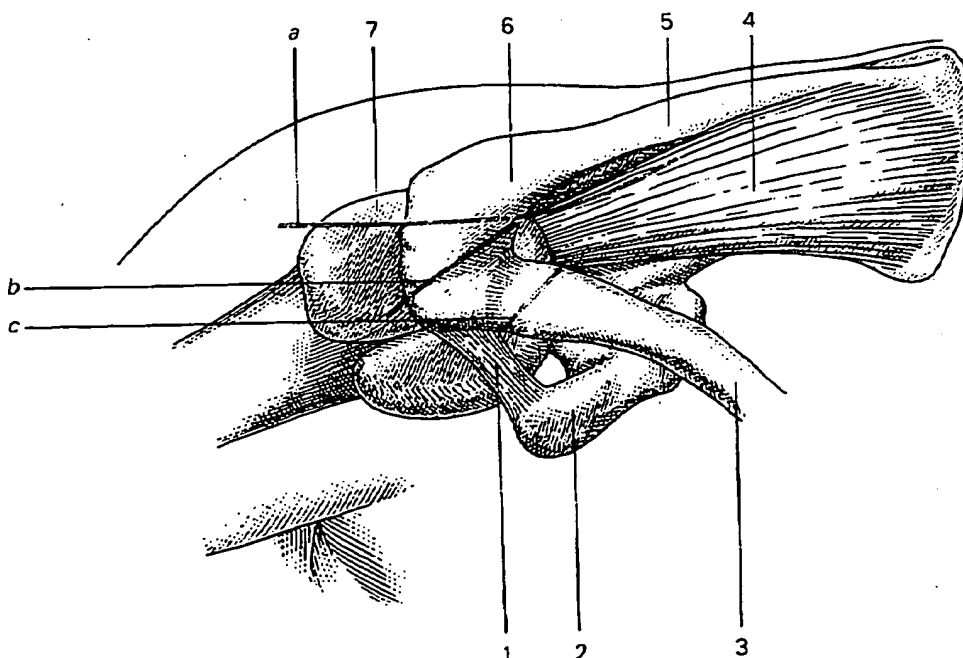
## Osteotomy of the acromion and clavicle

A An osteotomy of the acromion or clavicle may be required

for the exposure or decompression of the rotator cuff. The acromion should only be divided in the coronal plane and never in the sagittal plane. The osteotomy may be placed as shown:

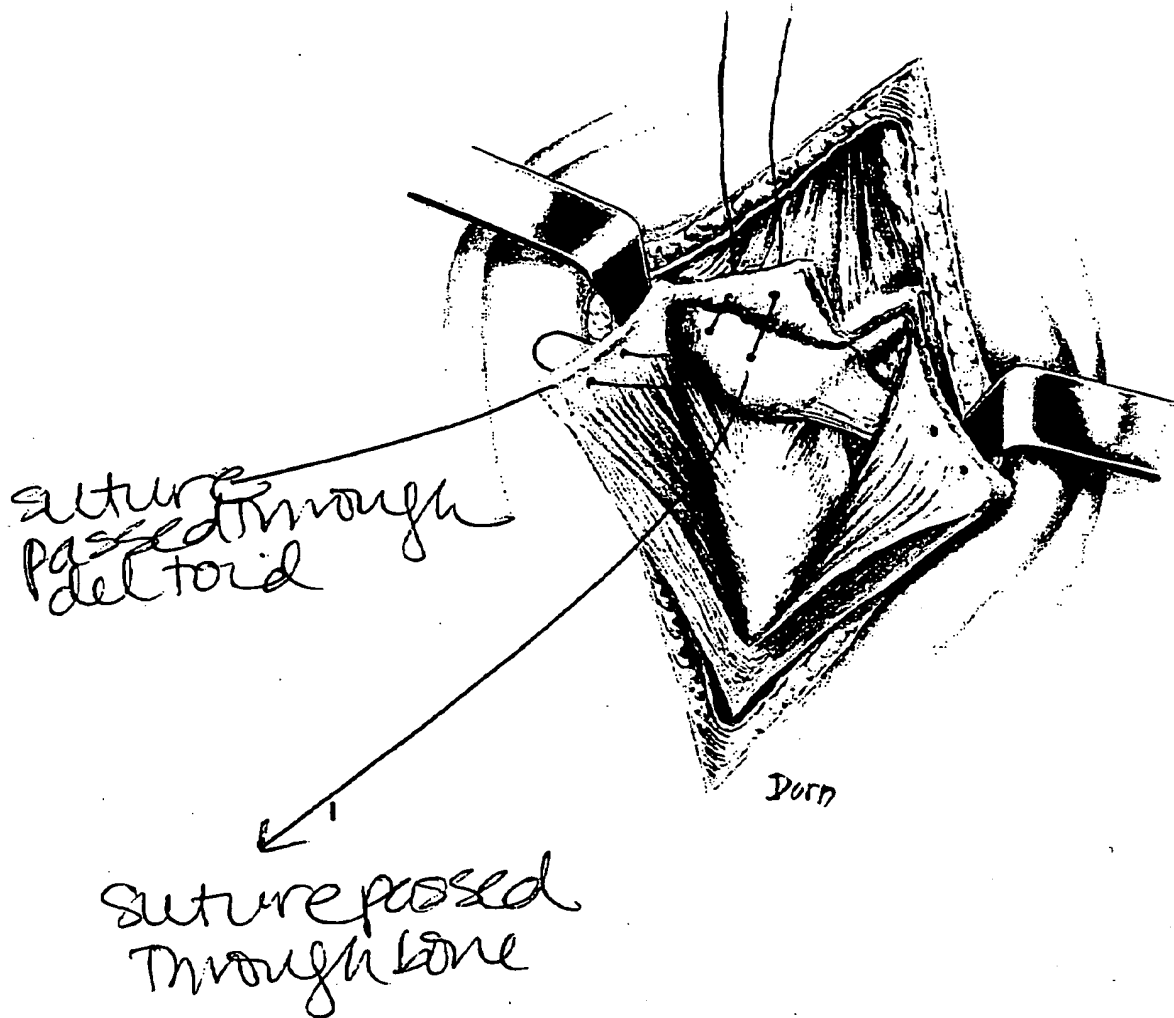
- Relatively posteriorly if supraspinatus is to be exposed.
- If the anterior acromion is to be excised, the osteotomy is sited towards the anterior margin and should be oblique, to preserve the deltoid origin.
- Division of the lateral clavicle should be oblique, leaving the anterior border longer than the posterior, which gives a more effective decompression of the rotator cuff than a transverse osteotomy.

Both the osteotomies of the clavicle and of the acromion recommended here run in the traction lines of the adjacent muscles and hence there is no danger of the cut bone ends being distracted with resultant delay in union of the osteotomy.



- A**
- 1 coracoacromial ligament
  - 2 coracoid process
  - 3 clavicle
  - 4 supraspinatus
  - 5 spine of scapula
  - 6 acromion
  - 7 subacromial bursa
- a,b osteotomy of acromion  
c osteotomy of clavicle

## Subacromial space: anterior



I The flaps can be reattached with sutures passed through the bone and thus the origin of deltoid may be reconstructed.

**Plastic/Reconstructive**



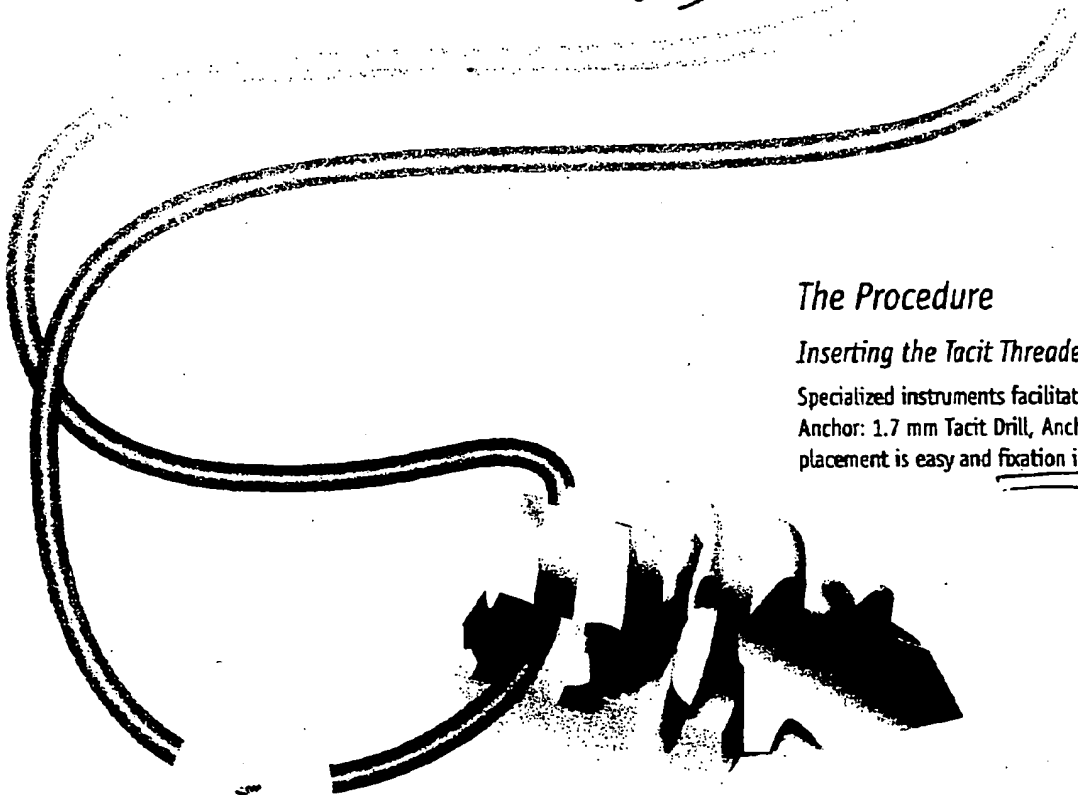
**Mitek®**

# The Mitek® 2.0 mm T

*Smaller Size. Superior Strength. Increased Safety.*

Plastic and reconstructive surgery is an exact art, demanding absolute accuracy for optimal alignment. Surgeons must be able to precisely reattach tissue to bone to realize optimal results, not be hampered by operative constraints. Patient safety is paramount, just as lasting results are critical. Yet, achieving all this is not always simple. That is why Mitek designed the 2.0 mm Tacit Threaded Anchor—its presence unspoken, its fixation secure.

*Threaded  
with suture  
always*



## *The Procedure*

### *Inserting the Tacit Threaded Anchor*

Specialized instruments facilitate placement of the Tacit Threaded Anchor: 1.7 mm Tacit Drill, Anchor Loop and Tacit Inserter. With these, placement is easy and fixation is secure.

Actual size:  
2.0 mm

# it<sup>TM</sup> Threaded Anchor

Tacit, a titanium alloy implant, locks suture in predrilled bone sites. Its miniaturized dimensions allow precise anatomical placement, simplifying intricate operations while facilitating a wide range of procedures from endoscopic brow lifts to scapholunate ligament reconstruction. Throughout the plastic and reconstructive fields, Tacit ensures optimal results.

## Small

Tacit's miniaturized size allows intra-operative flexibility, permitting the surgeon to select the location for optimal fixation.

## Strong (Fixation)

Tacit's fixation strength in cortical bone is more than twice the break strength of #2/0 suture.

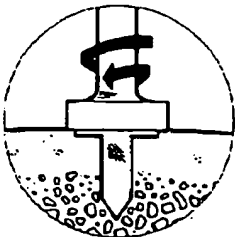
## Safe

With an anchor depth of only 4.0 mm, Tacit offers solid security, as proven in biomedical and clinical evaluations.

## Mitek

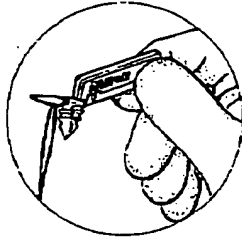
*Revolutionary Designs.  
Multispecialty Applications.  
The Gold Standard.*

Worldwide, Mitek Anchors set the gold standard for soft tissue reattachment. Mitek's unique proprietary suture anchor product lines enhance a wide range of surgical techniques, speeding operational success. That's why Mitek is the first name in suture anchors. \*



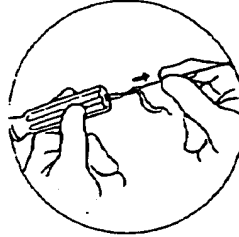
### Drill the Hole

Using the drill, prepare the anchor's insertion site.



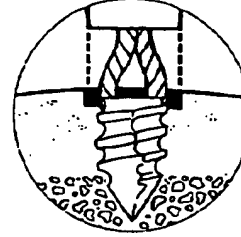
### Thread the Suture

- To attach a single strand of braided suture, 2/0 or smaller, to Tacit:
  - Pass the suture through threader tab wire.
  - Pull the anchor off the threader into the middle of the suture.
  - Discard the threader.
- To attach a monofilament suture, 3/0 or smaller, to Tacit:
  - Place the suture directly through the anchor eyelet.



### Attach Anchor to Loop

- Place Tacit with suture into the loop, leaving 5-6 inches of suture lead.
- Place the nonloop end into the hole in the metal tip of the inserter.
- Pull the loop through the inserter, grasping the non-loop end.
- Pull the suture taut while adjusting the anchor into the hex; this secures the anchor.




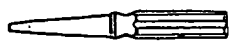
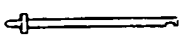

### Insert the Anchor

- Using the inserter, place the anchor tip into the drill hole and establish axial alignment.
- Twist inserter clockwise until anchor disengages (approximately four revolutions).
- Remove inserter.

# Mitek

*The First Name In Suture Anchors.*

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219120	Tacit Inserter 	1/box
211002	1.7 mm Tacit Drill 	1/box
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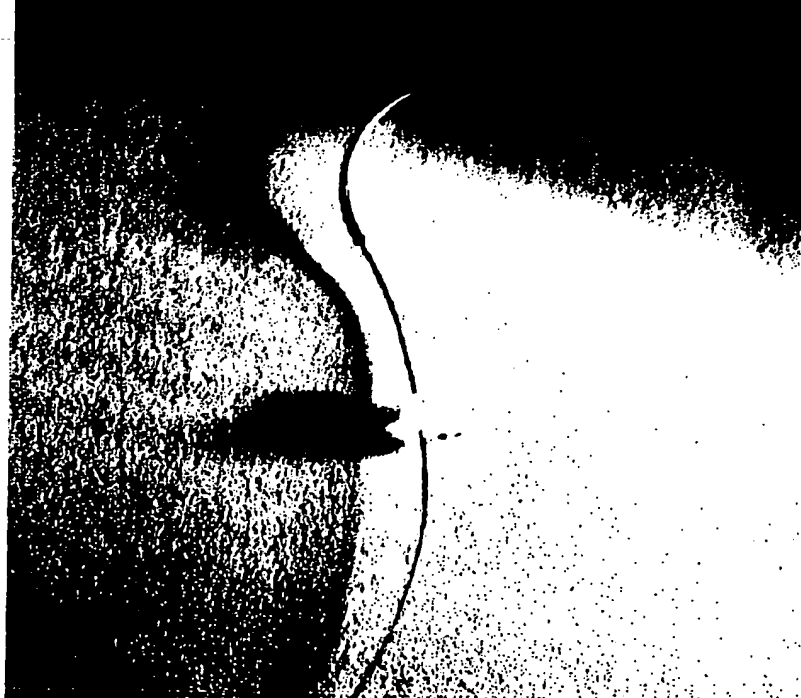
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*Resorbable Craniomaxillofacial Fixation*



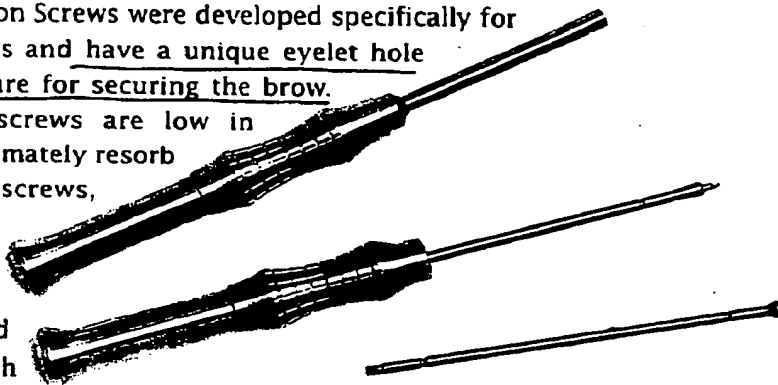
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*with a  
needle*

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 David Holck, MD: Willford Hall Medical Center, San Antonio, TX  
 Douglas Sinn, DDS: University of Texas, SW Medical School

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5. Fully insert the screw into the tapped hole until the head of the screw contacts the bone and the hex head detaches.
6. Pass the suture through the head of the screw. If a 3-0 or smaller suture is used, suture may be passed through the screw head using the suture needle. If a 2-0 suture is used, remove the needle and thread the suture through the screw head, then attach the suture to a suture needle.
7. Perform the elevation.



needle  
always  
required

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CE

PERMANENT  
TECHNIQUES IN  
UPPER EXTREMITY  
SPORTS INJURIES

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# OPERATIVE TECHNIQUES IN UPPER EXTREMITY SPORTS INJURIES

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### **Decision Making: Addressing the Capsular and Labral Pathology**

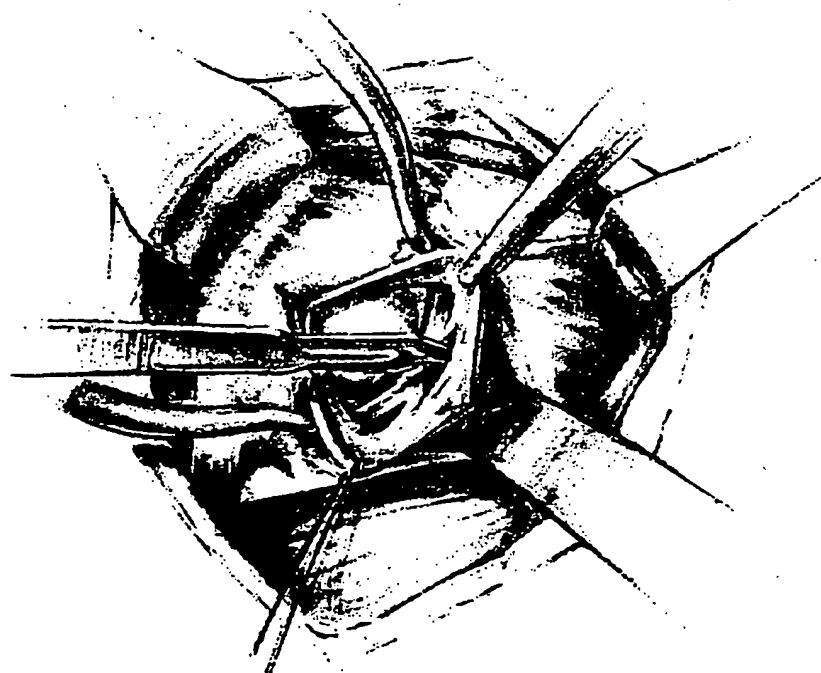
At this point the surgeon is required to make a decision based on the patient's history, findings on physical examination, and operative findings. The surgeon must decide the degree of capsular redundancy present and the need for capsular shift. In addition, the surgeon must determine the presence or absence of a Bankart lesion.

It is common for the athlete who has had isolated traumatic events in the absence of chronic microrepetitive trauma to have an isolated, complete Bankart lesion without significant capsular laxity. In this case the Bankart lesion itself may be repaired without performing a capsular shift. The Bankart lesion may subsequently be repaired through the exposure gained by the longitudinal capsulotomy. This allows the Bankart lesion to be repaired anatomically, preserving the underlying labrum if it is not damaged, and without shortening the capsule to effect a repair to bone. When a complete Bankart lesion is observed at the patient's diagnostic arthroscopy, repairing the lesion must become a part of the surgical plan. If the labrum is severely damaged and altered anatomically, it may be removed. In chronic cases the labrum may be absent and the avulsed capsule is repaired directly. Even in the presence of an excellent capsular shift performed laterally at the humeral head, one of the most common causes of reconstructive failures has been well

documented to be the presence of an unrepaired Bankart lesion.<sup>50,56,57,58</sup>

At the time of the patient's diagnostic arthroscopy, the integrity of the glenohumeral ligaments is evaluated. The importance of evaluating the ligaments in the patient with atraumatic instability has been emphasized, but the physician should also realize that the patient with traumatic instability and the presence of the Bankart lesion may have pathologic laxity and attenuation of the glenohumeral ligaments and capsule as well. In the presence of significant capsular laxity, repairing the Bankart lesion alone will not yield a stable joint, and problems of subluxation will continue.

When the longitudinal capsulotomy has been completed and the joint has been exposed, the glenoid labrum and capsule should be reevaluated to confirm the impressions gained at the examination, under general anesthesia and the arthroscopic evaluation. The glenoid labrum should be carefully palpated with a small probe to determine the presence or absence of a Bankart lesion that may not have been appreciated at the time of arthroscopy. The capsule must be palpated for its integrity, volume, and ability to tighten and buttress the anterior inferior joint margin during external rotation of the arm. At this time the surgeon decides the amount of the capsular shift. The operation may be tailored to the patient's degree of laxity.



**FIGURE 7-39** Exposure of the glenohumeral joint.

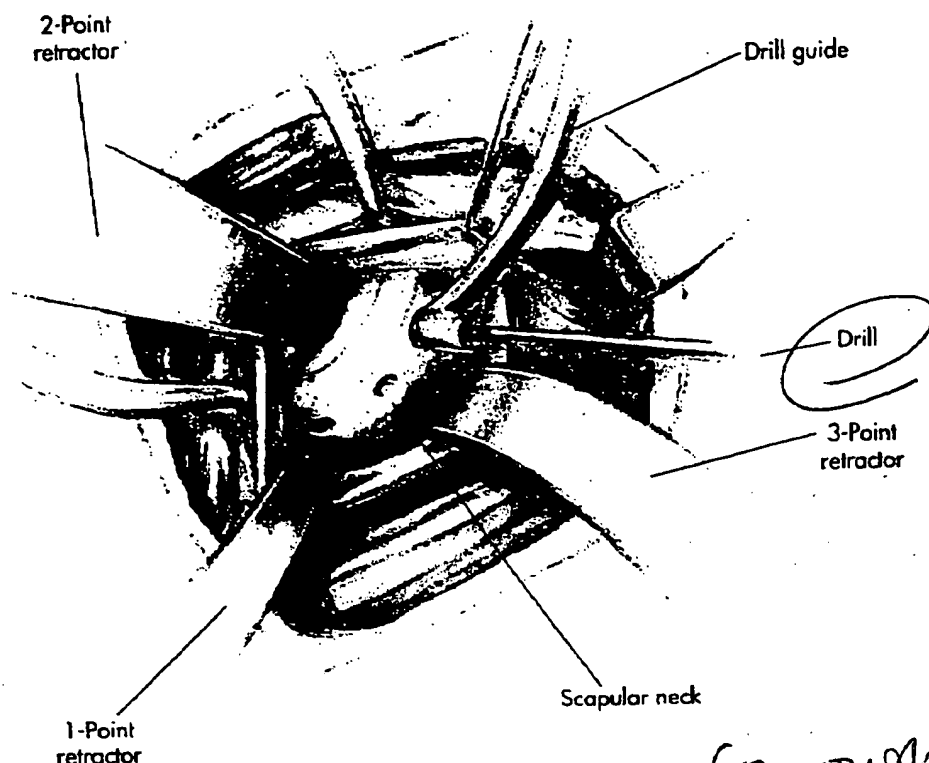


FIGURE 7-40 Drilling of the suture anchor holes.

(Through bone)

### Treatment of a Bankart Lesion

If a Bankart lesion (detachment of the anterior labrum and capsule) is present, the undersurface of the labrum should be roughened to promote healing of the labrum. The soft tissue and periosteum underneath and medial to the avulsed labrum and capsule is stripped to expose the bony anterior scapular neck. A curette and power burr may be used to abrade the anterior scapular neck and glenoid rim to provide a healing surface for fixation of the Bankart lesion.

The Bankart lesion is repaired by suture fixation to the prepared anterior scapular neck. This may be performed with the use of a curved spike-awl, as described by Rowe,<sup>46</sup> or by using a right-angle drill.<sup>20</sup> The holes along the anterior glenoid rim are usually placed at 3, 4, and 5 o'clock positions for the right shoulder (Fig. 7-40) and 9, 8, and 7 o'clock positions for the left shoulder. The preferred technique at this time for suture placement employs bony anchors\* (Fig. 7-41). The bone anchor allows for accurate placement of the sutures along the anterior scapular neck even in the presence of a significant

glenoid deficiency. An additional significant advantage of the bone anchor is the fact that the articular cartilage, along with anterior glenoid, does not have to be violated, as required with the use of standard Bankart instruments. The only disadvantage to using the bone anchor is the need for placement of a small metallic fixation device within the cancellous bone of the glenoid neck.

The #2 nonabsorbable suture should be used to reattach the avulsed labrum and capsule anatomically to the prepared scapular neck. By reattaching the labrum and medial capsule anatomically to the scapular neck, capsular shortening is avoided, and the potential for lost range of motion is minimized. The humeral head retractor is then removed, and the lateral portion of the capsule can be closed anatomically or with minimal overlap.

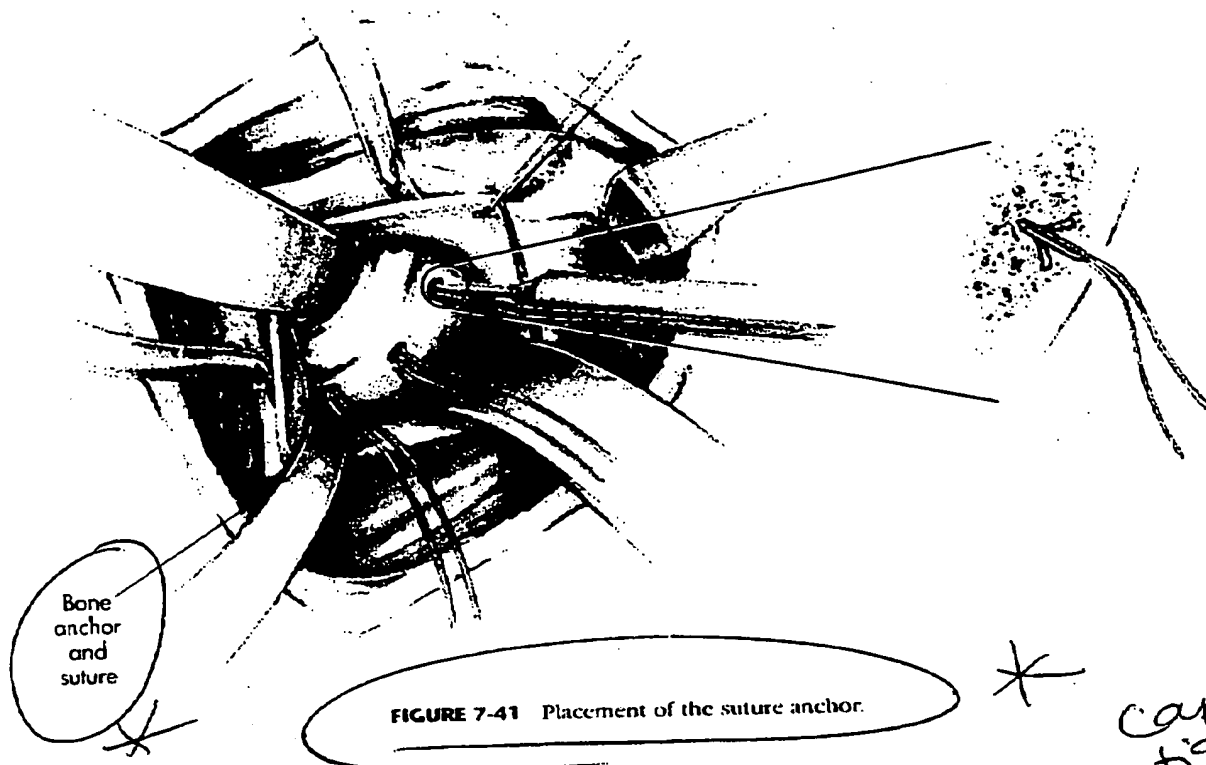
### Treatment of Capsular Laxity

After the joint has been exposed and the initial longitudinal capsulotomy performed, the capsule is inspected and palpated. At this point the capsule is confirmed as being lax or incompetent, thereby determining the decision to perform the capsular shift. In patients with microrepetitive atraumatic instability, the findings of capsu-

\*Mitek Surgical Anchor Products, Norwood, MA.

Suture fixation

Sutures are always repaired with suture-based anchors \*



lar laxity are typical in the absence of a Bankart lesion. The capsule must then be overlapped to obliterate the redundancy and allow the return of external rotation that is required for athletic function at the same time. This is accomplished by incising the capsule down onto the labrum and medial glenoid neck for subperiosteal elevation. This obviates a need for capsular shortening during its repair. Tag sutures have been placed at the margin of the capsulotomy just lateral to the labrum for easy identification.

At this time, exposure is facilitated by inserting a single-prong, narrow humeral head retractor. The humeral head retractor should be placed so the small, single prong is behind the inferior glenoid rim. Inferiorly, the axillary nerve is protected by using this retractor.

The inferior leaf of the capsular tissue contains most of the inferior glenohumeral ligament. This portion of the capsule is used to reconstruct the inferior ligament by advancing the tissue along the anterior glenoid rim and shifting it proximally. This technique also reinforces and adds to the anterior buttress and density of the labrum. The superior leaf of the capsule will later be brought distally over the inferior leaf and labrum, and then it will rest along the anterior scapular neck. The capsular repair is maintained by #2 nonabsorbable sutures from the anterior glenoid bone anchors (e.g., Mitek bone anchor).

Before the sutures are placed in the capsule, the capsule is advanced along the anterior glenoid rim and labrum in a superior direction again, avoiding any medial shortening of the capsule. The location of the capsule as it corresponds to the three previously placed sutures is noted to mark the location for a proper placement of the sutures in the inferior capsular leaf (Fig. 7-42). Beginning with the inferior suture, the sutures are brought through the medial edge of the capsule in the previously marked position with careful attention to protect the axillary nerve inferiorly with the use of the small single-point retractor. The sutures are always brought through capsular tissues under direct visualization. After the sutures have been placed, the repair should be tested by pulling tightly on the suture and noting the position of the capsule. The inferior capsular leaf should be noted to have been drawn superiorly, along the anterior rim of the glenoid, without moving the capsule medially along the scapular neck. The sutures are then tied, but not cut, because they will be used to anchor the superior capsular flap.

The superior capsular leaf is pulled over the inferior capsule repair (Fig. 7-43). As in the preparation of the inferior capsule, the location of the superior capsule and its relative position to the sutures are noted, and careful attention is paid to avoid moving the capsule medially as the sutures are brought through its substance. The

but only after  
penetrated through  
the flap

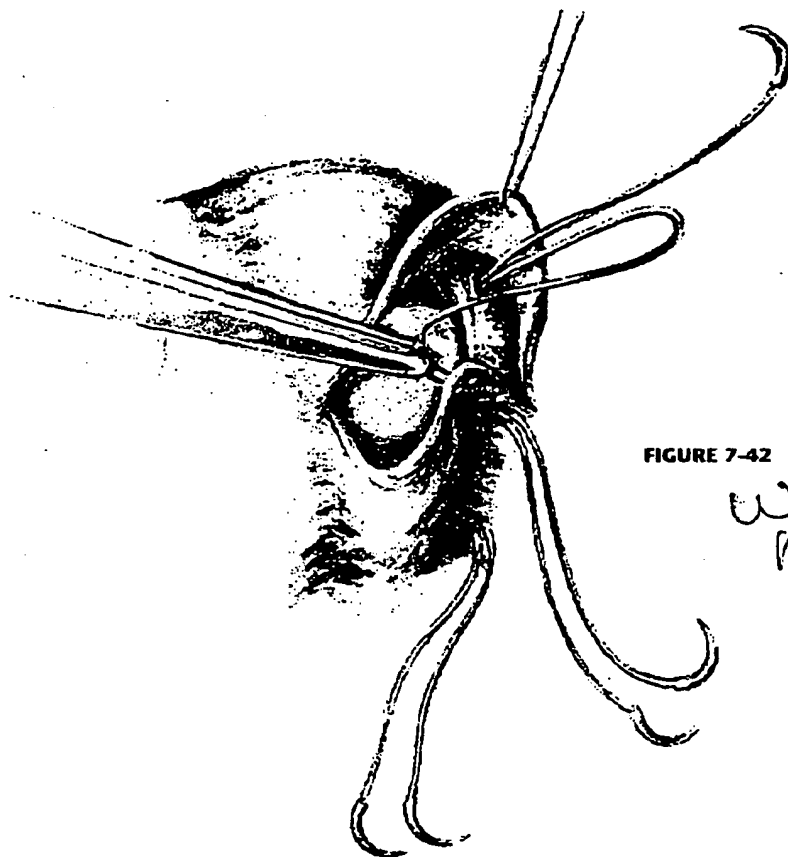


FIGURE 7-42 The inferior leaf is secured superiorly.

*with needles &  
sutures \**



FIGURE 7-43 The superior leaf is secured inferiorly.

humeral head retractor is then removed and the shoulder is brought through a range of motion to ensure that the repair of the superior capsule has not compromised the postoperative safe zone for range of motion. The sutures are tied and cut. The lateral expansion of the capsule is then repaired by bringing the superior capsule loosely over the inferior capsule with a vest-over-pants technique using nonabsorbable suture.

### **Treatment of a Combined Bankart Lesion and Capsular Laxity**

Because of the multitude of instability episodes, there may be distortion of the anatomy, including absence of the anterior glenoid labrum and/or a defect in the anterior glenoid rim. In the presence of a Bankart lesion (capsular avulsion from the anterior glenoid rim) or in the absence of the glenoid labrum, the repair is performed by securing the capsule to a prepared anterior scapular neck. Typically the capsule has become redundant, which necessitates not only a reattachment of the capsule to the scapular neck, but also a capsular shift. When performing a capsular shift in the absence of a labrum, the surgeon must ensure that the capsular shift reduces the anteroinferior capsular recess without excessively moving the capsule medially and losing postoperative range of motion.

### **Safe Zone Range of Motion Test**

On completion of the capsular closure, the arm is taken through a range of motion to determine the point where tension is placed on the repair. The patient may move within this safe zone after surgery without jeopardizing the reconstruction. This allows the athlete to begin an early range-of-motion program and avoid the complications of adhesions, capsular contraction, and atrophy, but at the same time protect the repair. This safe zone usually allows abduction above 90° in the scapular plane and external rotation beyond 45° before tension is placed along the repair. If at the completion of the procedure, an adequate safe zone is not allowed, the repair should be taken down and the sutures replaced. Usually when an adequate safe zone is not possible, it is because the sutures have been placed too lateral within the capsular flaps ultimately moving those capsular repairs medially or because the overflap is too tight.

### **Closure and Reapproximation of Subscapularis Muscle**

After completion of the capsular repair and observation of the safe zone, the Gelpi and pitchfork retractors are removed and replaced by a Goelet retractor laterally and a long Richardson retractor medially. The subscapularis is reapproximated with several interrupted #0 absorbable sutures (Fig. 7-44). All retractors are then removed after a thorough irrigation of the operative field. The deltoid and pectoralis muscles fall into place and

typically do not require suture reapproximation. The skin is closed in a subcuticular manner, sterile adhesive strips (Steri-Strips) are applied, and then a sterile dressing is applied.

The arm may then be placed in an adjustable orthotic device that splints the arm in abduction and external rotation, but the arm is removed for postoperative range of motion and bathing. The purpose of the splint is to prevent contraction of the capsule and loss of range of motion. In patients who have generalized ligament laxity, a shoulder abduction pillow at 45° is used because range of motion has been easy to gain. Patients with global multidirectional instability and generalized soft-tissue laxity do not require an abduction splint because their tissues stretch easily and they are able to regain postoperative range of motion.

### **SURGICAL TREATMENT: ARTHROSCOPY**

The techniques for arthroscopic stabilization<sup>29,31,53,56</sup> continue to improve as does the success, provided that the patient population is carefully selected. Many authors have recommended against the use of arthroscopic stabilization in the athlete involved in collision sports because of an increased recurrence rate.<sup>25,42</sup> Most published reports concerning arthroscopic stabilization have recommended that the procedure not be performed in patients with capsular laxity in the absence of a Bankart lesion. The results to date for arthroscopic reconstruction in the face of atraumatic instability have been poor, and arthroscopic reconstruction is not recommended in the overhead athlete with atraumatic instability.<sup>25,31,34</sup>

Two recent arthroscopic surgical techniques<sup>53,56</sup> have enjoyed an early success rate but lack long-term follow-up and have only been applied to a carefully selected patient population with a clean Bankart lesion in the absence of significant capsular laxity. The suture anchor technique<sup>56</sup> uses arthroscopically placed sutures to transfix a Bankart lesion and an arthroscopically placed Mitek bone anchor. Early results of this procedure in 20 patients demonstrated no complications and no recurrences of instability. The arthroscopic Bankart repair using a cannulated absorbable fixation device<sup>53</sup> uses an absorbable tack of polyglyconate, which is absorbed over 6 weeks. The overall recurrence rate of instability using this procedure in 26 patients has been 8%. Both of these procedures require postoperative immobilization for 3 to 4 weeks.

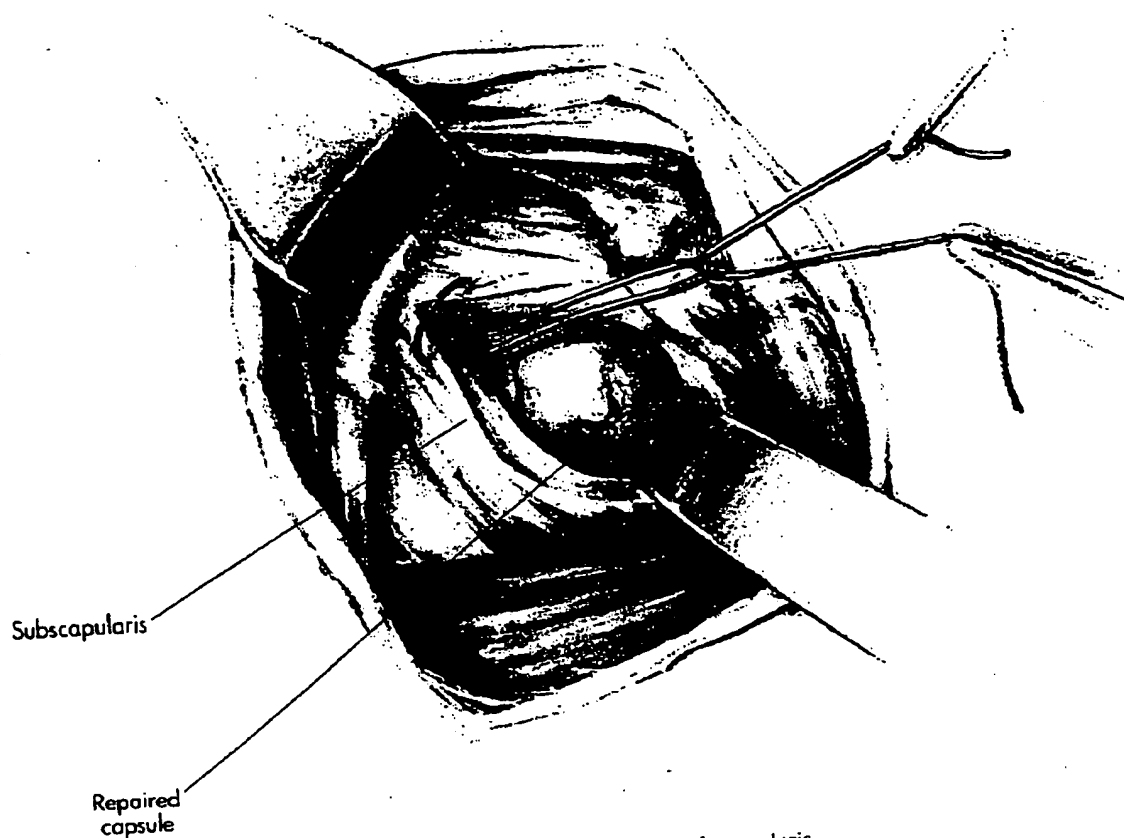
Unfortunately, the success rate of arthroscopic reconstruction to date has not matched the success rate for open procedures, especially in the athletic population. The duration of postoperative immobilization is greater in the arthroscopic technique than in the open technique. Undoubtedly, as arthroscopic techniques continue to develop with improved fixation in conjunction with

tack  
(suture)

X

X

sutures (ties)



**FIGURE 7-44** Closure of the subscapularis.

earlier range of motion, the role and indications for arthroscopic stabilization will continue to expand.

Labral lesions may certainly occur in the absence of obvious glenohumeral instability. Tears of the superior labrum may result from a superiorly directed force such as a fall on the outstretched arm. Snyder<sup>51</sup> has described an injury involving the superior aspect of the glenoid labrum beginning posteriorly and extending anteriorly (SLAP lesion). This area of the labrum was noted to be functionally important because it serves as an anchor for the insertion of the long head of the biceps tendon. SLAP lesions are not common, but when present they may be confused with anterior instability of the glenohumeral joint because of the presence of pain associated with overhead activities and the fact that often they may only be diagnosed at the time of arthroscopy. They frequently occur in conjunction with anterior instability and internal impingement.

The pain caused by a labral lesion is usually anterior, and there is often a "click" associated with range of motion. SLAP lesions are often seen in pitchers and overhead athletes; internal impingement of the rotator cuff

against the superior rim in overhead activities appears to be a common cause of this condition.

The SLAP lesion has been divided into the following four types: type 1 lesions involve fraying of the superior labrum with an intact peripheral labral edge and biceps tendon anchor, type 2 lesions involve fraying of the labrum, as well as detachment of the superior labrum and biceps tendon from the underlying glenoid, type 3 lesions demonstrate a bucket-handle tear of the superior labrum with an intact peripheral attachment and biceps tendon anchor, and type 4 lesions involve a bucket-handle tear of the superior labrum that extends into the biceps tendon and anchor.<sup>51</sup> The SLAP lesions involving an intact biceps tendon and labral attachment to the glenoid (types 1 and 3) may be treated with simple arthroscopic débridement of the torn labrum. When the biceps tendon and labral attachment to the glenoid have been disrupted (types 2 and 4), the treatment of choice is reattaching the biceps tendon and labral complex to the superior glenoid surface. The open technique to repair a type 2 or 4 SLAP lesion requires an osteotomy of the acromion and an approach in the interval between

- the supraspinatus and subscapularis. The displaced SLAP lesion can be treated with debridement of the superior glenoid rim and transfixation of the biceps tendon and labral complex with a cannulated absorbable fixation device" (Surtac) or fixation with sutures transfixing to a bony anchor.<sup>16</sup>
- X sutures*
- SUMMARY**
- The shoulder joint is vulnerable to traumatic and atraumatic instability because of the lack of bony constraints, and the joint's stability depends on the capsuloligamentous complex. Obtaining an accurate history and physical examination is critical in establishing the diagnosis of instability, as well as the direction and nature of pathological laxity. Arthroscopic evaluation is sometimes necessary to confirm the diagnosis, especially when occult subluxation is present. Treatment is predicated on an accurate diagnosis and begins with a well-supervised rehabilitation program. Surgery is reserved for patients who fail conservative therapy, except in unique circumstances where failure is predictable without surgery. Surgical reconstruction is very effective in controlling instability, and recent techniques have allowed athletes involved in overhead sports to return to their former competitive level. Arthroscopy has played an important role in the evaluation of the glenohumeral joint and the treatment of mechanical lesions, such as a superior labral tear. An open anterior capsulolabral reconstruction is currently the preferred technique for athletes with symptomatic anterior and multidirectional instability of the glenohumeral joint.
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considered among the most common causes of shoulder pain in the population under the age of 35. It is particularly common among individuals involved in repetitive overhead activities such as baseball, swimming, racquet sports, and volleyball. Although Neer's theory of impingement has been effective in the older population (in whom it was originally described), it has proven less helpful in understanding or successfully treating younger (less than 35 years) athletes with impingement. Differences in patient

has been found in younger patients as well and is consistent at the posterior superior labral rim) recently pinement (caused by undersurface cuff/labral impingement of chronic shoulder disability." However, impingement population in which it is the most common described, classified, and treated in an older, relatively shoulder pain. Traditionally such impingement has been structures, leading to mechanical wear and symptoms of the rotator cuff by surrounding bony and soft-tissue *Subacromial impingement* refers to encroachment of

## Subacromial Impingement: Clinical Assessment and Treatment

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Duration of physical therapy  
Results of nonoperative treatment  
Return to activity  
Preferred surgical treatment  
Surgical procedures and results  
Subacromial bursectomy  
Coracoclavicular ligament excision  
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Role of technique/activity/mechanics alterations  
Role of steroid injections

**Ninth New Collegiate Dictionary, A Merriam-Webster**

**Anchor:** to become fixed.

**Attach:** to bring (oneself) into an association; to assign temporarily; to make fast (as by *tying*).

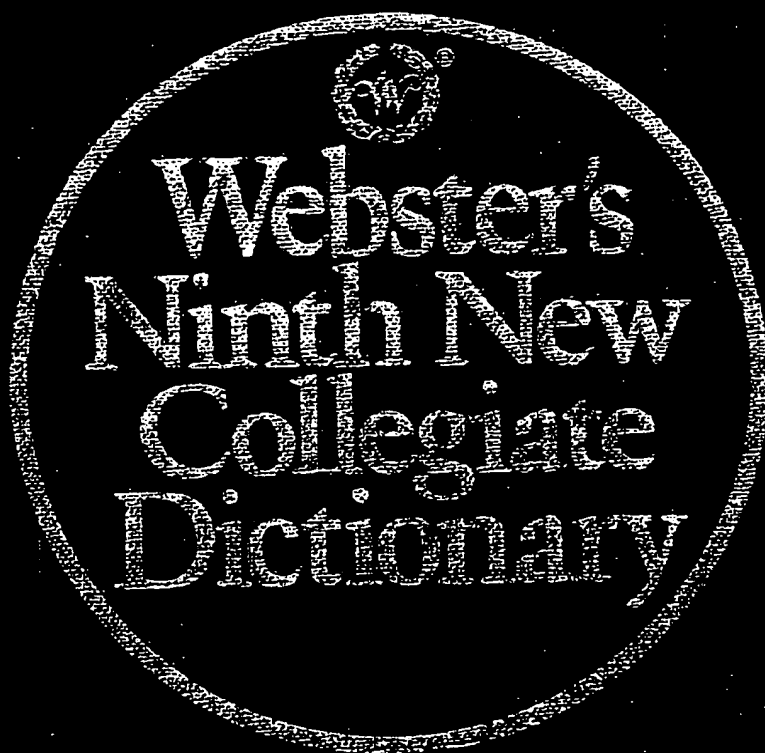
**Fasten:** implies an action such as *tying*.

**Fix** usually implies a driving in, implanting, or embedding (located as a comparison under **Fasten**)

**Attach** suggests a connecting or uniting by a bond, link *or tie* in order to keep things together.

**Suture:** A stitch made with a suture. A strand or fiber to sew parts of the body. The act or process of sewing with sutures. A uniting of parts. To unite, close, or secure with sutures.

**Tie:** a line, ribbon, or cord used for fastening, uniting, or drawing something closed, esp. shoelace. A method or style of tying or knotting. Something that is knotted or is to be knotted when worn (necktie). *To fasten, attach, or closed by means of a tie*; to form a knot or bow in (your scarf) to make by tying consistent elements (tied a wreath).



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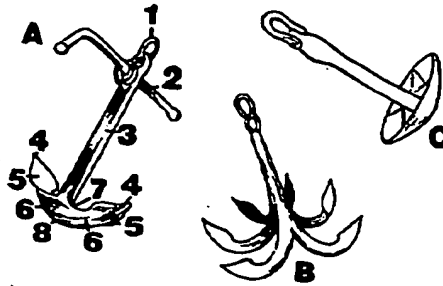
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**anchored** (an-'k(ə)-səd, an-'l n [L. fr. Gk. *Anchōnē*]: the father of Aeneas rescued by his son from the burning city of Troy  
**an-chor** ('an-'k(ə)-r) a. often attrib [ME *ancore*, fr. OE *ancor*, fr. L. *anchora*, fr. Gk. *ankura* — more at **ANGLE**] (bef. 12c) 1: a device usu. of metal attached to a ship or boat by a cable and cast overboard to hold it in a particular place by means of a fluke that digs into the bottom 2: a reliable or principal support 3: something that serves to hold an object firmly 4: an object shaped like a ship's anchor 5: an anchorman or anchorwoman 6 pl. *stang*: the brakes of a motor vehicle — **an-chor-less** \-'l(ə)-l(ə) *adj*



anchor 1: A yachtsman's; 1 ring, 2 stock, 3 shank, 4 bill, 5 fluke, 6 arm, 7 throat, 8 crown, B grapnel, C mushroom

**anchor** v. b. **an-chor-ed**; **an-chor-ing** \-'k(ə)-rɪŋ/ w (13c) 1: to hold in place in the water by an anchor 2: to secure firmly: **FIX** 3: to act or serve as an anchor for (need a large store ~ the mail) (*~ing the evening news*) ~ *v* 1: to cast anchor 2: to become fixed  
**an-chor-age** ('an-'k(ə)-rɪj) n (1587) 1: a place where vessels anchor 2: a place suitable for anchoring 3: the act of anchoring; the condition of being anchored 2: a means of securing; a source of reassurance (this ~ of Christian hope — T. O. Wedel) 3: something that provides a secure hold

**an-chor-ess** ('an-'k(ə)-rəs) or **an-chor-ess** \-'krəs/ n [ME *ankeresse*, fr. *anker* hermit, fr. OE *ancor*, fr. OIr *anchora*, fr. LL *anchoreta*] (14c): a female anchorite

**an-chor-ite** ('an-'k(ə)-rɪt) also **an-chor-ite** \-'rɪt/ n [ME, fr. ML *anchoreta*, alter. of LL *anchoreta*, fr. LGk *anachoreta*, fr. Gk *anachōreîn* to withdraw, fr. *ana-* + *chōreîn* to make room, fr. *chōros* place; akin to Gk *chōros* left, bereaved — more at **HEIR**] (15c): one who lives in seclusion usu. for religious reasons — **an-chor-ite** \-'k(ə)-rɪt-ik/ *adj* — **an-chor-ite-ly** \-'k(ə)-rɪt-ik-ly/ *adv*

**an-chor-man** ('an-'k(ə)-mən) n (1911) 1: one who is last: as: a: the member of a team who competes last (the ~ on a relay team) b: one who has the lowest scholastic standing in his graduating class 2: a broadcaster (as on a news program) who introduces reports by other broadcast and usu. reads the news 3: **MODERATOR** 2c

**an-chor-people** \-'p(ə)-p(ə)-l/ n pl (1974): **ANCHORPERSONS**

**an-chor-person** \-'p(ə)-p(ə)-n/ n (1973): **ANCHORPERSON**

**an-chor-woman** \-'w(ɒ)m-ən/ n (1973): a woman who anchors a broadcast

**an-cho-ve** also **an-cho-ve-ta** \-'n(ə)-v(ə)-t(ə)/ n [Sp *anchoveta*, dim. of *anchova*] (1940): a small anchovy (*Cetengraulis mytilus*) of the Pacific coast of No. America

**an-cho-ve** ('an-'ch(ə)-v(ə), an-'v(ə)-v(ə) n pl. *vies* or *-vies* [Sp *anchova*] (1596): any of numerous small fishes (family *Engraulidae*) resembling herrings; esp.: a common Mediterranean fish (*Engraulis encrasicolus*) used esp. in appetizers, as a garnish, and for making sauces and relishes

**an-cho-ve** ('an-'ch(ə)-v(ə), an-'v(ə)-v(ə) n [F. lit., old regime] (1794) 1: the political and social system of France before the Revolution of 1789 2: a system or mode no longer prevailing

**an-cient** ('an-'sh(ə)-nt, 'an-'sh(ə)-nt) *adj* [ME *ancien*, fr. MF, fr. (assumed) VL *antecum*, fr. L. *ante* before — more at **ANTE**] (14c) 1: having had an existence of many years 2: of or relating to a remote period, to a time early in history, or to those living in such a period or time; specif.: of or relating to the historical period beginning with the earliest known civilizations and extending to the fall of the western Roman Empire in A.D. 476 3: having the qualities of age or long existence: a: **VENERABLE** b: **OLD-FASHIONED**, **ANTIQU** *syn* see **OLD** — **an-cient-ness** n

**an-cient** n (1502) 1: an aged living being (a penniless ~) 2: one who lived in ancient times: a pl: the civilized people of antiquity; esp.: those of the classical nations 3: one of the classical authors (Plutarch and other ~s) 3: an ancient coin

**an-cient** n [alter. of *ensign*] (1554) 1 *archaic*: **ENSIGN**, **STANDARD**, **FLAG** 2 obs: the bearer of an *ensign*

**an-cient** n (1595) 1: the history of ancient times 2: knowledge or information that is widespread and has lost its initial freshness or importance: common knowledge

**an-cient-ly** *adv* (1502): in ancient times: long ago

**an-cient-ry** \-'rɪ/ n (1580): **ANTIQUITY**, **ANCIENTNESS**

**an-cil-la** ('an-'sɪ-l(ə)-l(ə) n pl. *-lae* \-'l(ə)-l(ə)/ [L. female servant] (1871): **AID**, **HELPER**

**an-cil-lary** ('an-'sɪ-l(ə)-l(ə)-rɪ, esp. Brit. 'an-'sɪ-l(ə)-rɪ) *adj* (1667) 1: **SUBORDINATE**, **SUBSIDIARY** (the main factory and its ~ plants) 2: **AUXILIARY**, **SUPPLEMENTARY** (the need for ~ evidence) — **an-cil-lary** n

**an-con** ('an-'k(ə)-n) n, pl. *-cones* \-'k(ə)-n(ə)-z/ [L. fr. Gk. *ankōn* elbow; akin to L. *uncus* hook] (ca. 1706): a bracket, elbow, or console used as an architectural support

**an-cy** ('an-'sɪ-) n n suffix [L. *-antia* — more at **ANCE**]: quality or state (piquancy)

**some mouth** — more at **ANGLE STOMACH**] (1887): infection disease caused by hookworms; esp.: a lethargic anemic state due to blood loss through the feeding of hookworms in the skin  
**and** ('ænd, 'ʌnd) *conj* (ME, fr. OE: akin to OHG *and* (bef. 12c) 1: used as a function word to indicate connection of items within the same class or type; used to join elements of the same grammatical rank or function 2: a function word to express logical modification, consequence, or supplementary explanation 3 obs: 1: used in logic to conjunction — and how \-'ænd-'haʊ/ — used to emphasize the idea — and so forth \-'ænd-'sɒ-'fɜ:th-, '-fɔ:rih/ 1: and others of the same or similar kind 2: further in the same or similar 3: and the rest 4: and other things — and so on \-'ænd-'sɒ-'ɒ/ and so forth

**AND** ('ænd) n (1949): a logical operator equivalent to the *con* connective and (~ gate in a computer)

**an-da-lu-si-a** \-'æn-'d(ə)-'li-si-ə/ n [F. *Andalousie*, fr. *Andalusie* An region in Spain] (ca. 1828): a mineral Al<sub>2</sub>SiO<sub>5</sub> consisting of a silicate of aluminum usu. in thick nearly square orthorhombic prisms of colors

**an-dan-té** ('æn-'d(ə)-'t(ə), '-d(ə)-t(ə)-t(ə) *adv* or *adj* [It. lit. *pp.* of *andare* to go] (1724): moderately slow — used as a *dire* music

**andante** n (1784): a musical composition or movement in a tempo

**an-dan-te-ao** \-'æn-'d(ə)-'t(ə)-'t(ə)-'t(ə)-'t(ə) *adv* or *adj* [It. dim. of *andante*]: slightly faster than *andante* — used as a direction in music

**andantino** n, pl. *-nos* (1845): a musical composition or movement in a tempo

**an-de-si-te** ('æn-'di-'zɪt/ n [G. *andesit*, fr. *Andes*] (1850): an extrusive dark grayish rock consisting essentially of oligoclase or feldspar

**an-dit** ('æn-'dɪt) *adj* [ME *aundiren*, modif. of MF *andier*]: one of a pair of metal supports for firewood used on a hearth made of a horizontal bar mounted on short legs with usu. a shaft surmounting the front end

**and/or** ('ænd-'ɔ: or 'ænd-'ɔ:/ *conj* (1855) — used as a function word to indicate that two words or expressions are to be taken together or individually (punishable by a fine and/or a term in jail)

**and/or** or **and/or-omb** form [MF, fr. L. fr. Gk. fr. *andr*, *anēr* man (akin to Oscan *ner* man, Skt *nṛ*, OIr *ner* strength) 1: man (phobia) 2: male (*androecium*)

**an-dro-dite** ('æn-'dr(ə)-dɪt/ n [J. B. de Andrada e Silva (1838 Brazilian geologist)] (1868): a garnet Ca<sub>2</sub>Fe<sub>2</sub>(SiO<sub>6</sub>) of various colors ranging from yellow and green to brown and black

**Andro-cles** ('æn-'dr(ə)-k(ə)-l(ə) n [L. fr. Gk. *Androkles*]: a fabled slave spared in the arena by a lion from whose foot he had years later extracted a thorn

**an-dro-e-cium** ('æn-'dr(ə)-sh(ə)-əm) n, pl. *-cia* \-'sɪ(h)-ə/ [NL, fr. *and* Gk. *oikos*, dim. of *oikos* house — more at **VICINITY**] (ca. 1839) aggregate of microsporophylls in the flower of a seed plant

**an-dro-gen** ('æn-'dr(ə)-j(ə)-n) n [SV] (1936): a male sex hormone (as testosterone) — **an-dro-gen-ic** ('æn-'dr(ə)-j(ə)-n-ik) *adj*

**an-dro-gen-esis** ('æn-'dr(ə)-j(ə)-n-ə-'sɪs/ n (ca. 1900): development in the embryo contains only paternal chromosomes due to failure of egg to participate in fertilization — **an-dro-gen-etic** \-'j(ə)-n-ɪk-ik/ *adj*

**an-dro-gyne** ('æn-'dr(ə)-jɪn/ n [MF, fr. L. *androgynus*] (1552): one that is androgynous

**an-dro-gynous** ('æn-'dr(ə)-jɪn-əs) *adj* [L. *androgynus* hermaphrodite Gk. *androgynos*, fr. *andr* + *gynē* woman — more at **QUEEN**] (165) having the characteristics or nature of both male and female; neither specifically feminine or masculine (the ~ pronoun *they* suitable to or for either sex (~ clothing) 3: having traditional and female roles obscured or reversed (an ~ marriage) — **an-drog-** \-'n(ə)-/ *n*

**an-droid** ('æn-'dr(ə)-ɪd) n [LGk. *andros* manlike, fr. Gk. *andr* + *oidēs* -oid] (1727): an automaton with a human form

**an-drom-a-che** ('æn-'dr(ə)-m(ə)-'tʃ(ə)-k(ə) n [L. fr. Gk. *Andromachē*]: the wife of Hector

**an-drom-e-da** ('æn-'dr(ə)-m(ə)-d(ə)-'d(ə) n [L. fr. Gk. *Andromeda*] 1: a mythological Ethiopian princess rescued from a monster by her future husband Perseus 2 [L. (gen. *Andromedae*)] a northern constellation directly south of Cassiopeia between Pegasus and Perseus

**an-dros-ter-one** ('æn-'dr(ə)-st(ə)-r(ə)-'n(ə)-n/ n [SV *andr* + *sterol* — *one*] (1: an androgenic hormone that is a hydroxy ketone C<sub>19</sub>H<sub>26</sub>O<sub>2</sub> from human male and female urine

**an-drous** ('æn-'dr(ə)-s) *adj* *comb* form [NL. *andrus*, fr. Gk. *andros* man (such or so many) men, fr. *andr*, *anēr*]: having (such or so many) stamens (*monandrous*)

**ane** ('æn) *adj* or *n* or *pron*, chiefly Scot. (bef. 12c): **ONE**

**-ane** ('æn) n suffix [SV *-an*, *-ane*, alter. of *-ene*, *-ine*, & *-one*] 1: a (tolane) 2: saturated or completely hydrogenated carbon compo (as a hydrocarbon) (methane)

**an-ec-dot-age** ('æn-'ik-'d(ə)-t(ə)-j(ə) n (1823): the telling of anecdotes; **ANECDOTES**

**an-ec-dot-al** ('æn-'ik-'d(ə)-t(ə)-l(ə) *adj* (1836) 1: relating to, characteristic or containing anecdotes 2: having the form or style of anecdotes; depicting an anecdote (~ art) — **an-ec-dot-ably** \-'l(ə)-l(ə)-l(ə) *adv*

**an-ec-dot-ist** ('æn-'ik-'d(ə)-t(ə)-sɪt/ n or **an-ec-dot-ist** ('æn-'ik-'d(ə)-t(ə)-sɪt/ n (1837): one who is given to or is skilled in telling anecdotes

**an-ec-dote** ('æn-'ik-'d(ə)-t(ə) n [F. fr. Gk. *anekdota* unpublished items, neut. pl. of *anekdotos* unpublished, fr. *a-* + *ekdidōnai* to publish, fr. out + *didōnai* to give — more at **EX-DAT**] (1721): a usu. short narrative of an interesting, amusing, or biographical incident

**an-ec-dot-ic** ('æn-'ik-'d(ə)-t(ə)-ik/ or **an-ec-dot-ic-al** \-'d(ə)-t(ə)-ik-əl/ *adj* (1786) **ANECDOTAL** 2: given to or skilled in telling anecdotes — **an-ec-dot-ic-ally** \-'d(ə)-t(ə)-ik-əl-ly/ *adv*

**an-ech-ic** ('æn-'i-'k(ə)-k(ə)-k(ə) *adj* (1946): free from echoes and reverberations (an ~ chamber)

**a-tōny** \ˈat-ə-nē\ n [LL *atonia* fr. Gk. fr. *atonos* without tone]. fr. *a-* + *tonos* tone] (1693) : lack of physiological tone esp. of a contractile organ  
**atop** \ə-ˈtɒp/ prep (1655) : on top of  
**atop adv** or **adj** (1638) : on, to, or at the top  
**at-o-py** \ˈat-ə-peɪ\ n [Gk *atopy* uncommonness, fr. *atopos* out of the way, uncommon, fr. *a-* + *topos* place — more at TOPIC] (1923) : a probably hereditary allergy characterized by symptoms (as asthma, hay fever, or hives) produced upon exposure to the exciting antigen without inoculation  
**atropic** \ə-ˈtri-pik/ adj  
**-ator** *n* suffix [ME *-atur*, fr. OF & L; OF, fr. L *-ator*, fr. *-atus* -ate + *-or*] : one that does (totalizer)  
ATP \ä-ˈti-peɪ, -ti-peɪ\ n [adenosine triphosphate] (1944) : a phosphorylated nucleotide C<sub>10</sub>H<sub>16</sub>N<sub>5</sub>O<sub>17</sub>P<sub>3</sub> of adenine that supplies energy for many biochemical cellular processes by undergoing enzymatic hydrolysis esp. to ADP — called also *adenosine triphosphate*  
ATPase \ä-ˈti-pe-ās-, -äs\ n (1946) : an enzyme that hydrolyzes ATP; esp.: one that hydrolyzes ATP to ADP and inorganic phosphate  
**atra-bilious** \ə-ˈtrā-bil-yəs/ adj [*atra bilis* black bile] (1651) 1 : given to or marked by melancholy : GLOOMY 2 : ILL-NATURED, PEEVISH ~ *atra-biliousness* *n*  
**atrazine** \ə-ˈtrā-zēn\ n [ISV *atr.* (prob. fr. L *atr.*, *ater* black, dark) + *triazine*] (1962) : a photosynthesis-inhibiting persistent herbicide C<sub>6</sub>H<sub>8</sub>ClN<sub>4</sub> used esp. to kill annual weeds and quack grass  
**atrem-ble** \ə-ˈtre-m-blə/ adj (1862) : shaking involuntarily : TREMBLING (He was white as death and all) — Robert Coover  
**atrocity** \ə-ˈtro-si-ti/ n [L *atrocitas* : fr. Gk *atros* perlocution, fr. *setaimien* to pierce — more] (1807) 1 : absence or closure of a natural passage of the body 2 : absence or disappearance of an anatomical part (as an ovarian follicle) by degeneration  
**Atræus** \ä-ˈtrūs-, -trə-s\ n [Gk.] : a king of Mycenae and father of Agamemnon and Menelaus  
**atrio-ventric-u-lar** \ä-ˈtrē-ō-ven-ˈtrik-yə-lər-, -vən-/ adj [NL *atrium* + E *ventricular*] (ca. 1860) : of, relating to, or located between an atrium and ventricle of the heart  
**atrioventricular muscle** *n* (ca. 1934) : a small mass of tissue in the right atrioventricular region of higher vertebrates through which impulses from the sinoatrial node are passed to the ventricles  
**atrip** \ə-ˈtrip/ adj, of an anchor (1796) : a weaver  
**atrium** \ä-ˈtrē-əm\, *n* pl *atria* \-ˈtrē-ə\ also **strā-ums** [L] (1557) 1 : the central hall of a Roman house 2 [NL, fr. L] : an anatomical cavity or passage; esp.: the chamber or either of the chambers of the heart that receives blood from the veins and forces it into the ventricle or ventricles — see HEART illustration 3 pl *ustriums* : a rectangularly shaped open patio around which a house is built; also : a many-stoned court in a building (as a hotel) usu. with a skylight — *atrial* \-ˈtrē-əl/ adj  
**atro-cious** \ə-ˈtrō-shəs/ adj [L *atroc.*, *atrox* gloomy, atrocious, fr. *atr.*, extremely wicked, brutal, or cruel : *ops* eye] — more at EYE] (1669) 1 : extremely wicked, brutal, or cruel : BARBARIC 2 : APPALLING, HORRIFYING (the weapons of modern war) 3 a : utterly revolting : ABOMINABLE (~ working conditions) b : of very poor quality (~ handwriting) — *atrociously* *adv* — *atrociousness* *n*  
**atrocitous** \ə-ˈtrō-si-təs\, *n* pl *ties* (1534) 1 : the quality or state of being atrocious 2 : an atrocious act, object, or situation (the sufferings and atrocities of trench warfare — Aldous Huxley)  
**atrophy** \ä-ˈtro-fi\, *n* pl *-phies* [LL *atrophia*, fr. Gk. fr. *atrophos* ill fed, fr. *a-* + *trophen* to nourish; akin to Gk. *chromas* clot, curd] (1601) 1 : decrease in size or wasting away of a body part or tissue; also : arrested development or loss of a part or organ incidental to the normal development or life of an animal or plant 2 : a wasting away or progressive decline : DEGENERATION (the atrophy of freedom) (was not a solitude of ~, of negation, but of perpetual flowering — Willa Cather) — *atrophic \ä-ˈtro-fik/ adj  
**atropine** \ä-ˈtro-pin\, *n* [G *atropin*, fr. NL *Atropa*, genus name of belladonna, fr. Gk *Atropos*, one of the three Fates] (1836) : a racemic mixture of hyoscyamine from belladonna and related plants used esp. in the form of its sulfate to inhibit the actions of acetylcholine in the parasympathetic nervous system (as by relieving spasms of smooth muscle or dilating the pupil of the eye)  
**at-tach** \ə-ˈtʌtʃ/ vb [ME *attachen*, fr. MF *attacher*, fr. OF *estachier*, fr. *estache* stake, of Gmc origin; akin to OE *stoca* stake] w (14c) 1 : to take by legal authority esp.: under a writ (the court's sheriffs ~ed his property) 2 a : to bring (oneself) into an association b : to assign temporarily 3 a : to bind by personal ties (as of affection or sympathy) (was strongly ~ed to his family) 4 : to make fast (as by tying or gluing) (a label to a package) 5 : to associate esp. as a property : ATTRIBUTE (~ great importance to public opinion polls) ~ vi : to become attached : ADHERE *syn* see FASTEN — **at-tach-able** \ə-ˈtʌtʃ-ə-bəl/ adj  
**at-tache** \ä-ˈtʃə-, -ʃä-, -ä-, -tə-, -tä-/ n [F, pp. of *attacher*] (1829) 1 : a technical expert on the diplomatic staff of his country at a foreign capital (a military) ~ 2 ATTACHE CASE  
**at-tach-e case** \ä-ˈtʃə-, -ʃä-, -ä-, -tə-, -tä-/ *n* (1904) : a small thin suitcase used esp. for carrying business papers  
**at-tached** \ə-ˈtʌtʃ-d/ adj (1834) : permanently fixed when adult (~ barnacles)  
**at-tach-ment** \ə-ˈtʌtʃ-men-t\ *n* (15c) 1 : a seizure by legal process; also : the writ or precept commanding such seizure 2 a : the state of being personally attached : FIDELITY (~ to a cause) b : affectionate regard (a deep ~ to nature) 3 : a device attached to a machine or implement 4 : the physical connection by which one thing is attached to another 5 : the process of physically attaching  
**at-tack** \ə-ˈtʌk/ vb [MF *attaquer*, fr. (assumed) Old *ostaccare* to attack, fr. *stacca* stake, of Gmc origin; akin to OE *staca* w (1600) 1 : to set upon forcefully 2 : to threaten (a piece in chess) with immediate capture or destruction 3 : to begin to attack (with unkindly or bitter words) 4 : to begin to al-*

[illegible]

[illegible]

# 1190 sustentation • swanned

thelial cell (as a Sertoli cell or a cell of the olfactory epithelium) that lacks a specialized function (as nerve-impulse conduction)

**sus-ten-ta-tion** \-'tā-shən/ *n* [ME. fr. MF. fr. L. *sustentatio*, *sustentatio* act of holding up, fr. *sustentare*, pp. of *sustentare* to hold up, fr. *sustentare* pp. of *sustentare* to sustain] (14c) 1: the act of sustaining; the state of being sustained: as a: MAINTENANCE, UPKEEP b: PRESERVATION, CONSERVATION c: maintenance of life, growth, or morale d: provision with sustenance 2: something that sustains: SUPPORT — *sus-ten-ta-tive* \-'tā-shən-, -tā-iv, -sə-'stent-ət-/ *adj*

**sus-ten-doo** \-'stēn-choo/ *n* [fr. *sustain*, alter such pairs as E retain: retention] (1868): SUSTENTATION

**Susu** \-'sū-/ *n*, pl *Susu* or *Susos* (1920) 1: a member of a West African people of Mali, Guinea, and the area along the northern border of Sierra Leone 2: the language of the Susu people

**sus-sur-rus** \-'sū-sə-'rā-shən/ *n* (15c): a whispering sound: MURMUR

**sus-sur-rus** \-'sū-sə-'rā-shən/ *adj* (1839): full of whispering sounds

**sus-sur-rus** \-'sū-sə-'rā-shən/ *n* [L. hum. whisper — more at SWARM] (1831): a whispering or rustling sound — *sus-sur-rus* \-'sū-sə-'rā-shən/ *adj*

**sut-ler** \-'sū-tl-ər/ *n* [obs. D *soetler*, fr. LG *suteler* sloppy worker, camp cook; akin to OE *soetlra* to dirty, Gk *hēin* to rain — more at SUCK] (1599): a civilian provisioner to an army post often with a shop on the post

**sut-ra** \-'sū-trā-/ *n* [Skt *sūtra* thread, string of precepts, sutra; akin to L *sutrum* to sew — more at SEW] (1801) 1: a precept summarizing Vedic teaching; also: a collection of these precepts 2: a discourse of the Buddha

**sut-tee** \-'sū-tē-/ *n* [Skt *sati* wife who performs suttee, lit., good woman, fr. fem. of *sat* true, good; akin to OE *sāth* true, more at SOOTH] (1786): the act or custom of a Hindu widow willingly being cremated on the funeral pyre of her husband as an indication of her devotion to him; also: a woman cremated in this way

**sut-ture** \-'sū-cher-/ *n* [MF & L. MF. fr. L. *sutura* seam, suture, fr. *sutur*, pp. of *sutere* to sew — more at SEW] (1541) 1: a stitch made with a suture 2: a strand or fiber used to sew parts of the living body c: the act or process of sewing with sutures 2: a: an incision of parts b: the seam or seamlike line along which two things or parts are sewed or united 3: a: the line of union in an immovable articulation (as between the bones of the skull); also: such an articulation b: a furrow at the junction of adjacent bodily parts; esp: a line of dehiscence (as on a fruit) — *sut-ture* \-'sū-cher-/ *adj* — *sut-ture* \-'sū-cher-/ *adv*

**suture** *vi* \-'sū-tur-/ *adj* (1777): to unite, close, or secure with sutures (~ a wound)

**suz-er-a-in** \-'sū-zə-'rān, -rān/ *n* [F. fr. (assumed) MF *suzerain*, fr. MF *suzas* up (fr. L. *surgere*, fr. *sub* up + *versum* ward, fr. neut. of *versus*, pp. of *vertere* to turn) + *-erain* (as in *sovereign* sovereign) — more at SUB-] (1807) 1: a superior feudal lord to whom fealty is due 2: OVERLORD 3: a dominant state controlling the foreign relations of a vassal state but allowing it sovereign authority in its internal affairs

**suz-er-a-in-ry** \-'sū-zə-'rān-ē-/ *n* [F. *suzeraineté*, fr. MF *suzereneté*, fr. (assumed) MF *suzerain*] (1822): the dominion of a suzerain: OVERLORDSHIP

**swed-berg** \-'swēd-bərg-/ *n* [The Swedberg] (1939): a unit of time amounting to 10<sup>-10</sup> second that is used to measure the sedimentation velocity of a colloidal solution (as of a protein) in an ultracentrifuge and to determine molecular weight by substitution in an equation — called also *swedberg unit*

**swelt** \-'swelt-/ *adj* [F. fr. It *swella*, fr. pp. of *swellere* to pluck out, modif. of L *cellere*, fr. *c-* + *vellere* to pluck — more at VULNERABLE] (1817) 1: a: SLENDER, LITHE b: having clean lines: SLEEK 2: URBANE, SUAVE — *swelt-ly* *adv* — *swelt-ness* *n*

**Sven-gali** \-'sven-gā-lē-/ *n* [Svengali, maleficent hypnotist in the novel *Trilby* (1894) by George du Maurier] (ca. 1945): one who attempts us. with evil intentions to persuade or force another to do his bidding

**swab** \-'swāb-/ *n* [prob. fr. obs. D *swabe*, akin to LG *swabber* mop] (1653) 1: a mop; esp: a yarn mop b: (1) a wad of absorbent material usu. wound around one end of a small stick and used for applying medication or for removing material from an area (2): a specimen taken with a swab c: a sponge or cloth patch attached to a long handle and used to clean the bore of a firearm 2: a useless or contemptible person b: SAILOR, DOG

**swab** *vi* \-'swāb-/ *adj* [back-formation fr. *swabber*] (1719) 1: to clean with or as if with a swab 2: to apply medication to with a swab (*swabbed* the wound with iodine)

**swab-ber** \-'swāb-ər-/ *n* [akin to LG *swabber* mop, ME *swabben* to sway] (1592) 1: one that swabs 2: SWAB 2a

**swab-ble** \-'swāb-əl-/ *n* [akin to pl *swabbies* slang (1944): SWAB 2b

**swad-dle** \-'swād-dl-/ *vi* *swad-dled*; *swad-dling* \-'swād-dl-ig, -'ig/ [ME *swadelen*, *swathelen*, prob. alter. of *swadelen*, *swathelen*, fr. *swathel* swaddling band, fr. OE: akin to OE *swathan* to swathe] (14c) 1: to wrap (an infant) with swaddling clothes b: ENVELOP, SWATHE 2: RESTRAIN, RESTRICT

**swad-dling** \-'swād-dl-ig-/ *n* pl (1535) 1: narrow strips of cloth wrapped around an infant to restrict movement 2: limitations or restrictions imposed on the immature or inexperienced

**swag** \-'swāg-/ *n* *swagged*; *swag-ging* [prob. of Scand origin; akin to ON *svagga* to cause to sway; akin to OHG *swangan* to swing] (ca. 1530) 1: SWAY, URCH 2: SAG

**swag** *n* (1660) 1: SWAY 2: a: something (as a decoration) hanging in (overgreen branches) 3: a: goods acquired by unlawful means: LOOT b: SPOLLS, PROFITS 4: a depression in the earth 5 chiefly Austral: a pack of personal belongings

**swage** \-'swāj-, 'swēj-/ *n* [ME, ornamental border, fr. MF *soaige*] (ca. 1812): a tool used by metalworkers for shaping their work by holding it on the work or the work on it and striking with a hammer or sledge

**swage** *vi* \-'swāj-/ *adj* (1831): to shape by or as if by means of a swage

**swage block** *n* (1843): a perforated cast-iron or steel block with grooved sides that is used in heading bolts and swaging bars by hand

**swag-ger** \-'swāg-ər-/ *vb* *swag-gered*; *swag-ger-ing* \-'swāg-ig-/ *n* [prob. fr. *swag* + *-er* (as in *charter*)] *n* (1590) 1: to conduct oneself in an arrogant or superciliously pompous manner; esp: to walk with an air of overbearing self-confidence 2: BOAST, BRAG ~ *w*: to force by argu-

ment or threat: BULLY — *swag-gerer* \-'swāg-ə-r-/ *n* — *swag-ger-ing-ly* \-'swāg-ig-ig-/ *adv*

**swag-ger** *adj* (1725): marked by elegance or showiness: POSH

**swag-ger** *n* (1879) 1: a: an act or instance of swaggering b: arrogant or conceited self-assured behavior c: ostentatious display or bravado 2: a self-confident outlook: COCKINESS

**swag-ger stick** *n* (1887): a short light stick usu. covered with leather and tipped with metal at each end and intended for carrying in the hand (as by military officers)

**swag-ward** \-'swāg-wərd-/ *n*, chiefly Austral (1879): WANDERER; esp: one who carries a swag when traveling

**Swahili** \-'swā-hē-lē-/ *n*, pl *Swahili* or *Swahilis* [Ar *swahilī*, pl. of *sāhilī* coast] (1814) 1: a member of a Bantu-speaking people of Zanzibar and the adjacent coast 2: a Bantu language that is a trade and governmental language over much of East Africa and in the Congo region

**swain** \-'swān-/ *n* [ME *swain* boy, servant, fr. ON *swain*; akin to OE *swān* swain, L *swans* one's own — more at SUICIDE] (1579) 1: RUSTIC PEASANT; specif: SHEPHERD 2: a male admirer or suitor — *swain-ish* \-'swā-nish-/ *adj* — *swain-ish-ness* *n*

**swale** \-'swāl-/ *n* [ME, shade, prob. of Scand origin; akin to ON *swāl* cool; akin to OE *swelan* to burn — more at SWELTER] (1584): a low lying or depressed and often wet stretch of land

**swallow** \-'swāl-/ *n*, -'swāl-/ *n* [ME *swallowe*, fr. OE *swelgan* to swallow] (12c) 1: to take through the mouth and esophagus into the stomach 2: to envelop or take in as if by swallowing: ABSORB 3: to accept without question, protest, or resentment (~ an insult (a hard story to ~)) 4: TAKE BACK, RETRACT (had to ~ my words) 5: to keep from expressing or showing: REPRESS (~ed my anger) 6: to utter (as words) indistinctly ~ *vi* 1: to receive something into the body through the mouth and esophagus 2: to perform the action characteristic of swallowing something esp. under emotional stress — *swallow-able* \-'swāl-ə-bəl-/ *adj* — *swallow-er* \-'swāl-ə-wər-/ *n*

**swallow** *n* (14c) 1: the passage connecting the mouth to the stomach 2: a capacity for swallowing 3: a: an act of swallowing b: an amount that can be swallowed at one time 4: an aperture in a block on a ship between the sheave and frame through which the rope reeves

**swallow-tail** \-'swāl-ə-tāil-/ *n* (1703) 1: a deeply forked and tapering tail (as of a swallow) 2: TAILCOAT 3: any of various large butterflies (esp. genus *Papilio*) with the hind wing produced into a process resembling a tail

**swallow-tail** \-'swāl-ə-tāil-/ *adj* (1703) 1: of the shape of the pods] (1578): CELANDINE 1



swallow 1

**swamp** \-'swāmp-/ *n* [Hindi *swāmi*, fr. Skt *svāmin* owner, lord, fr. *swa* one's own — more at SUICIDE] (1895) 1: a Hindu ascetic or religious teacher; specif: a senior member of a religious order — used as a title 2: one that resembles or emulates a swami: FUNDTR. SEER

**swamp** \-'swāmp-/ *n* [alter. of ME *swamp*, fr. MD *swamp* morass; akin to MHG *swamp* marsh, Gk *swamp* spongy] (1624) 1: wet spongy land saturated and sometimes partially or intermittently covered with water 2: a tract of swamp — *swamp* *adj*

**swamp** *vi* (1772) 1: a: to fill with or as if with water: INUNDATE b: to overwhelm numerically or by an excess of something c: FLOOD (~ed with work) 2: to open by removing underbrush and debris ~ *vi*: to become submerged

**swamp buggy** *n* (1941): a vehicle used to negotiate swampy terrain: as a: an amphibious tractor b: a flat-bottomed boat driven by an airplane propeller

**swamper** \-'swāmp-ər-, 'swāmp-/ *n* (1735) 1: a: an inhabitant of swamps or lowlands b: one familiar with swampy terrain 2: a general assistant: HANDYMAN, HELPER

**swamp-land** \-'swāmp-land-/ *n* (1663): SWAMP 1

**swampy** \-'swāmp-ē-/ *adj* *swamp-ier*, -est (1649): consisting of or resembling swamp: MARSH — *swamp-iness* *n*

**swan** \-'swān-/ *n*, pl *swans* [ME, fr. OE: akin to MHG *swan*, L *sonus* sound — more at SOUND] (bef. 12c) 1: pl *also* swan: any of various heavy-bodied long-necked mostly pure white aquatic birds (family Anatidae) that are related to but larger than the goose, walk awkwardly, fly strongly when once started, and are graceful swimmers 2: one that resembles or is likened to a swan 3: cap: the constellation Cygnus

**swan** *vi* *swanned*; *swan-ning* (ca. 1940): to wander aimlessly: DALLY

**swan** *n* *swanned*; *swan-ning* [perh. euphemism for *swear*] *dialect* (1784): DECLARE, SWEAR

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**tick** *n* [ME *teck*: akin to *MHG* *zie* light push] (15c) 1 *a*: a light rhythmic audible tap or beat; also: a series of such ticks *b* chiefly *Brit*: the time taken by the tick of a clock; **MOMENT** 2: a small spot or mark; *esp*: one used to direct attention to something, to check an item on a list, or to represent a point on a scale  
**tick w** (1721) 1: to make the sound of a tick or a series of ticks 2: to operate as a functioning mechanism 3: **RUN** (tried to understand what made him ~) (the motor was ~ing over quietly) ~ *w* 1: to mark with a written tick: **CHECK** ~ usu. used with *off* (~ed off each item in the list) 2: to mark, count, or announce by or as if by ticking (as a meter ~ing off his cab fare)  
**tick** *n* [short for 'ticked'] (1642): **CREDIT, TRUST**; also: a credit account  
**tick-borne** *ˈtɪk-ˌbɔːrn, -ˌbɔːrɪn* *adj* (1939): capable of being transmitted by the bites of ticks (~mencephalitis)  
**ticked** *ˈtɪkəd* *adj* (ca. 1688) 1: marked with ticks: **FLECKED** 2 of a ticked off (tick off) (ca. 1959): **ANGRY, UPSET**  
**ticker** *ˈtɪk-ər* *n* (1828): something that ticks or produces a ticking sound; *as*: **WATCH** *b*: a telegraphic receiving instrument that automatically prints off information (as stock quotations or news) on a paper ribbon *slang*: **HEART**  
**ticker tape** *n* (1902): the paper ribbon on which a telegraphic ticker prints off its information  
**ticket** *ˈtɪk-ət* [*obs*: *F* *étiquette* (now *étiquette*), notice attached to something, *fr.* *MF* *assigner*, *fr.* *étriquer* to attach, *fr.* *MD* *steken* to stick; akin to *OHG* *sticken* to stick — more at **STICK**] (1529) 1 *a*: a document that serves as a certificate, license, or permit; *esp*: a mariner's or airman's certificate *b*: **TAG, LABEL** 2 *a*: a certificate or token showing that a fare or admission fee has been paid *b*: a means of access or passage (education is the ~ to a good job) 3: a list of candidates for nomination or election: **SLATE** 4: the correct or desirable thing (cooperation, that's the ~ — *K. E. Trombly*) 5: a ship's card recording a transaction or undertaking or giving instructions (a savings deposit ~) 6: a summons or warning issued to a traffic-law violator  
**ticket w** (1611) 1: to attach a ticket to: **LABEL**; also: **DESIGNATE** 2: to furnish or serve with a ticket (~ed for illegal parking)  
**ticket agency** (*ca.* 1934): an agency selling transportation or theater and entertainment tickets  
**ticket agent** *n* (1861) 1: one who acts as an agent of a transportation company to sell tickets for travel by train, boat, airplane, or bus 2: one who sells theater and entertainment tickets  
**ticket office** *n* (1666): an office of a transportation company, theatrical or entertainment enterprise, or ticket agency where tickets are sold and reservations made  
**tick-et-of-leave** *ˈtɪk-ət-(v)-ˈli:v* *n*, *pl* tickets-of-leave (1732): a license or permit formerly given in the United Kingdom and the British Commonwealth to a convict under imprisonment to go at large and to labor for himself subject to certain specific conditions  
**tick fever** *n* (ca. 1897) 1: **TEXAS FEVER** 2: a febrile disease (as Rocky Mountain spotted fever) transmitted by the bites of ticks  
**tickling** *ˈtɪk-ɪŋ* *n* ('tick') (1649) 1: a strong linen or cotton fabric used in upholstering and as a covering for a mattress or pillow  
**tickling** *n* ('tick') (1885): ticked marking on a bird or mammal or on individual hairs  
**tickles** *ˈtɪk-əl* *vb* tick-les; tickling *ˈtɪk-(ə)-lɪŋ* [ME *tikelen*: akin to OE *trickian* to tickle *w* (14c) 1: to have a tingling or pricking sensation (my back ~s) 2: to excite the surface nerves to prickle ~ *w* 1 *a*: to excite or stir up agreeably: **PLEASE** (music... does more than ~ our sense of rhythm — *Edgar Allan Poe*) *b*: to provoke to laughter or merriment: **AMUSE** (were tickled by the clown's antics) 2: to touch (as a body part) lightly so as to excite the surface nerves and cause uneasiness, laughter, or spasmodic movements  
**tickles** *n* (1801) 1: the act of tickling 2: a tickling sensation 3: something that tickles  
**tickler** *ˈtɪk-(ə)-lə* *n* (1680) 1: a person or device that tickles 2: a device for jogging the memory; *specif*: a file that serves as a reminder and is arranged to bring matters to timely attention  
**tickler coil** *n* (1922): small coil connected in series with the plate circuit of an electron tube and inductively coupled with its grid circuit to return a part of the amplified signal for repeated amplification  
**ticklish** *ˈtɪk-(ə)-lɪʃ* *adj* (1581) 1 *a*: **TOUCHY, OVERSENSITIVE** (~ about his baldness) *b*: easily overturned (a canoe is ~) *c*: crafty 2: requiring delicate handling: **CRITICAL** (a ~ subject) 3: sensitive to tickling — *ticklishly* *adv* — *ticklishness* *n*  
**tick off** *w* ('tick') (ca. 1919) 1: **REPRIMAND, REBUKE** (his father ticked him off for his impudence) 2: to make angry or indignant (the cancellation really ticked me off)  
**tick-tock** *ˈtɪk-tək* *n* ('tick') (ca. 1562): **COREOPSIS**  
**tick-tock or tick-tak** *ˈtɪk-tək* *n* [redupl. of 'tick'] (1549) 1: a ticking or tapping sound like that of a clock or watch 2: a contrivance used by children to tell on a window from a distance  
**tick-tock-toe** also **tick-toe-toe** *ˈtɪk-tək-təʊ* *n* [*fr.* *tic-tac-toe* (former game in which players with eyes shut brought a pencil down on a slate marked with numbers and scored the number hit in compartments (ca. 1866): a game in which two players alternately put Xs and Os in the compartments of a figure formed by two vertical lines crossing two horizontal lines and each tries to get a row of three Xs or three Os before the opponent does)  
**tick-tock** *ˈtɪk-tək, -tək* *n* [imit.] (1848): the ticking sound of a clock  
**tick tread** *n* ('tick') (1857): any of various leguminous plants (*Genus Desmodium*) with trifoliate leaves and rough sticky loment  
**tick-tacky** *ˈtɪk-ɪ-kə-tək* also **tick-tack** *ˈtɪk-tæk* *adj* 1: *pl* ticky-tackies also ticky-tacks [redupl. of 'tacky'] (1962): sleazy or shoddy material used esp. in the construction of look-alike tract houses; also: something built of ticky-tacky  
**tickytacky** also **tickytack** *adj* (1964) 1: of an uninspired or monotonous sameness 2: **TACKY** 3: built of ticky-tacky  
**tidal** *ˈtɪd-əl* *adj* (1807) 1 *a*: of, relating to, caused by, or having tides (~ cycles) *b*: periodically rising and falling or flowing and ebbing (~ waters) 2: dependent (as to the time of arrival or departure) upon the state of the tide (a ~ steamer) — *tid-ally* *ˈtɪd-əl-ē* *adv*  
**tidal wave** *n* (1830) 1 *a*: an unusually high sea wave that sometimes follows an earthquake *b*: an unusual rise of water alongshore due to

strong winds 2 something overwhelming (as a sweeping majority vote or an irresistible impulse)

**tide-bit** \tīd-,bit-*n* (perch. fr. *ti-* (as in *timouse*) + *bi-*) (1640) 1: a choice morsel of food 2: a choice or pleasing bit (as of news)

**tide-blyde-winkles** or **tide-dy-winkles** \tīd-,lī(-),wīŋ(k)s/, tīd-,lē-,wīŋ(k)s/*n pl* *but sing in constr* (prob. fr. E dial. *riddy-tiddle*) (1898) : a game whose object is to snap small disks from a flat surface into a small container

**tide** \tīd-/ *n*, *f*: OE *tīd*; akin to OHG *zīt* time, Gk *daiesthai* [to divide] (bef. 12c) 1: a obs.: a space of time; PERIOD 2: a fit or opportune time 3: OPPORTUNITY *c*: an ecclesiastical anniversary or festival; also: its season — usu. used in combination (*Easter tide*) 2: (1): the alternate rising and falling of the surface of the ocean and of water bodies (as gulfs and bays) connected with the ocean that occurs usu. twice a day and is caused by the gravitational attraction of the sun and moon 2: arising unequally on different parts of the earth (2): a less marked rising and falling of an inland body of water (3): a periodic movement in the earth's crust caused by the same forces that produce ocean tides (4): tidal distortion on one celestial body caused by the gravitational attraction of another (5): one of the tidal movements of the atmosphere resembling those of the ocean and produced by gravitation or diurnal temperature changes — called also *atmospheric tide* 3: FLOOD TIDE *v*: something that fluctuates like the tides of the sea (the ~ of public opinion) 4: *a*: a flowing stream : CURRENT *b*: the waters of the ocean *c*: the overflow of a flooding stream — tideless \-ləs/*adj*

**tide vb** *tīd*-ed; *tīd*-ing *vi* (1593) 1: to flow as or in a tide : SURGE 2: *i*: to drift with the tide esp. in navigating a ship into or out of an anchorage, harbor, or river ~ *vt* 1: to cause to float with or as if with the tide 2: to proceed along (one's way) by taking advantage of tides

**tide w** *tīd*-ed; *tīd*-ing [*ME* *tiden*, fr. OE *tīdan*; akin to MD *tiden* to go, *tīden* to come, OE *tīd* time] *archaic* (bef. 12c) : *TIDESE*. BEFALL

**tide-land** \tīd-,lānd-, -lānd/ *n* (1802) 1: land overflowed during flood tide 2: a land underlying the ocean and lying beyond the low-water limit of the tide but being within the territorial waters of a nation — often used in pl.

**tide-mark** \-mārk/ *n* (1799) 1: *a*: a high-water or sometimes low-water mark left by tidal water or a flood 2: *a*: a mark placed to indicate this point 2: the point to which something has attained or below which it has receded (the ~ of tolerance has risen — *New Republic*)

**tide over vt** \tīd-(ə)- / (ca. 1909) : to enable to surmount or endure a difficulty (money to tide us over the emergency)

**tide table n** (1594) : a table that indicates the height of the tide at one place at different times of day throughout one year

**tide-water** \-wōt-,ər-, -wāt-/ *n* (1772) 1: water overflowing land at low tide; also: water affected by the ebb and flow of the tide 2: low-lying coastal land

**tide-way** \-wā-/ *n* (1798) : a channel in which the tide runs

**tiding** \tīd-(ŋ)/ *n* [*ME*, fr. OE *tīdung*, fr. *tīdan* to betide] (bef. 12c) : *a*: a tidings *b*: usu. used in pl. (good ~s)

**tidy** \tīd-(ē)- / *adj* *tid*-der; -est [*ME*, timely, in good condition, fr. *tyde* time] (13c) : properly filled out : PLUMP 2: adequately satisfactory (an acceptable solution to their problem) 3: neat and methodical PRECISE (*a tidy mind*) 4: LARGE SUBSTANTIAL (*a tidy profit*) — tidily \tīd-,lī-, -lē- / *adv* *tid*-dly; *tid*-d-sən / *n*

**tidy vb** *tīd*-ed; *tīd*-ing *vt* (1821) : to put in order — up a room) — *vi* to make things tidy (~ing up after supper) — tidler *n*

**tidy n** *tī* (-dies) (ca. 1828) 1: a receptacle for sewing materials or odds and ends 2: a piece of fancywork used to protect the back, arms, or endstitch of a chair or sofa from wear or soil

**tidy-tips** \tīd-(ē)-tīps/ *n pl* *but sing or pl in constr* (1888) : an annual California composite herb (*Layia platyglossa*) having yellow-rayed flower heads often tipped with white

**tie** \tī-/ *n* [*ME* *tege*, fr. OE *tīg*; akin to ON *tang* rope, OE *tēon* to fasten, untie, or draw something closed]; esp.: SHOELACE *b* (1) : a structural element (as a rod or angle iron) holding two pieces together : a tension member in a construction (2) : one of the transverse supports to which railroad rails are fastened to keep them in line *y* : something that serves as a connecting link; as : a moral or legal obligation to someone or something typically constituting a restraining power, influence, or duty *b* : a bond or tie of kinship or affection 3 : a curved line that joins two musical notes of the same pitch to denote a equality in number (as of votes or scores) *b* : equality in a contest; as : a contest that ends in a draw 5 : a method or style of tying or knotting 6 : something that is knotted or is to be knotted when worn : *a*: NECKTIE *b*: a low laced shoe : OXFORD — tie-fied \tī-,fīd-/ *adj* *tie* close by means of a tie *b* : to form a knot or bow in — your scarf) — to make by tying constituent elements (fried a wreath) (~ a fishing net) 2 : to place or establish in relationship : CONNECT *b* : to unite (marriage) *c* : to unite (musical) notes by a tie *d* : to join (power lines) electrically 3 : to restrain from independence or freedom of action or choice : constrain by or as if by authority, influence, agreement, or obligation 4 : (1) : to make or have an equal score with in a contest (2) : to equalize (the score) in a game or contest (3) : to equalize the score of a game (4) : to provide or offer something equal : EQUAL ~ *vi* : to make a tie; as : to become attached — *d* : to close by means of a tie — tie into : to attach with vigor — tie one on slang : to drink — tie the knot : to perform a marriage ceremony; also : to marry

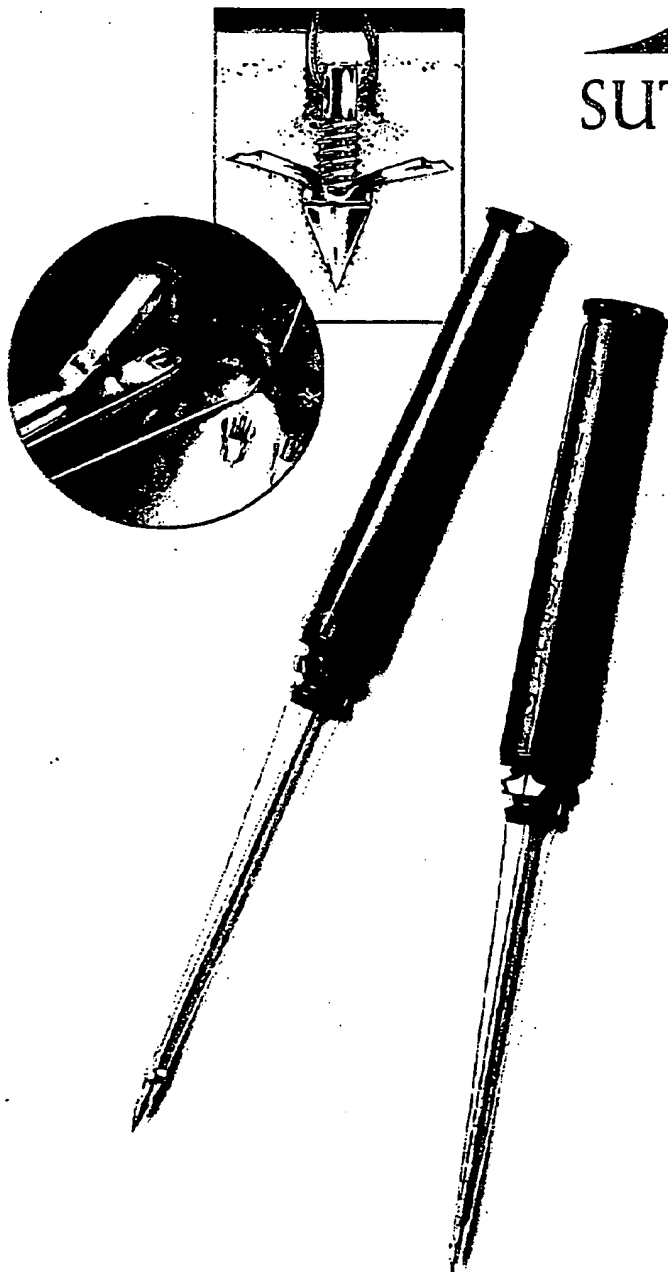
**tie-dye** \tī-,də-, dī-/ *n* (1928) : TIE-DYEING

**tieback** \tī-,bak/ *n* (1926) 1: a decorative strip or device of cloth, cord, or metal for draping a curtain to the side of a window 2 : a stain with a tieback — usu. used in pl.

[illegible]

*Leadership in...*

**HARPOON®**  
SUTURE ANCHORS

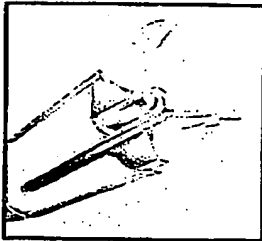


**ARTHROTEK®**  
AN INTEGRAL PART OF BIOMET'S WORLDWIDE TEAM

# One Step Anchor Insertion

- Direct impaction into bone:  
*Collared Harpoon*
- Impaction through soft tissue:  
*Collarless Harpoon*
- Soft tissue fixation when size and space are limitations: *Mini Harpoon*
- Ability to customize your suture anchor:  
*Limited Re-Usable Harpoon Handle*
- Surface capture in osteoporotic bone:  
*Cancellous Umbrella Harpoon™*
- Collared, Collarless, and Mini Harpoons come pre-assembled with a disposable driver, sutures, and needles, saving valuable set-up time to enhance surgical efficiency.
- Driver shaft designed to work in open and arthroscopic procedures to meet all surgical needs.

Needles  
&  
Sutures \*



- Suture slides through eyelet, aiding knot tying, especially arthroscopically.



## Collared Harpoon

- Impaction to the collar seats the anchor 10-12mm below the surface of the patient's cortical bone.

## Collarless Harpoon

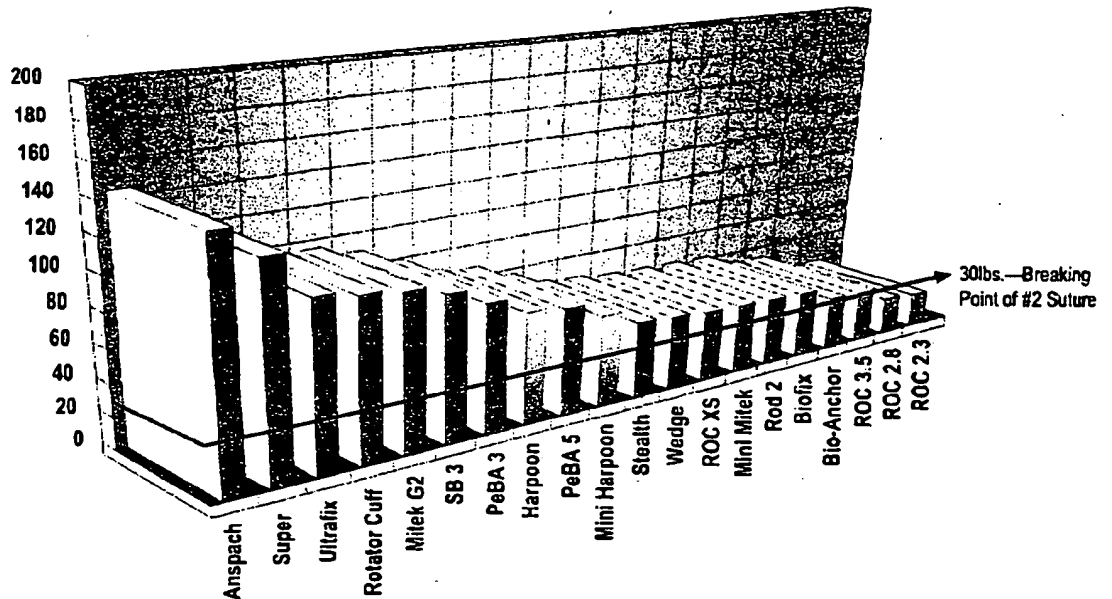
- Surgeon impacts anchor directly through the soft tissue, eliminating the need for suture passers.
- Shaft on Collarless Harpoon calibrated for anchor depth on insertion.

# *HARPOON*

*SOFT TISSUE ANCHOR SYSTEM*

*We've Got Your Suture Anchor Needs Covered*

**Diaphyseal Cortex<sup>1</sup>**



**No pre-drilling!**

*Advantage Harpoon*

**No instrumentation!**

*Advantage Harpoon*

**No special inserters!**

*Advantage Harpoon*

**No searching for drill holes!**

*Advantage Harpoon*

**Unlimited Options**

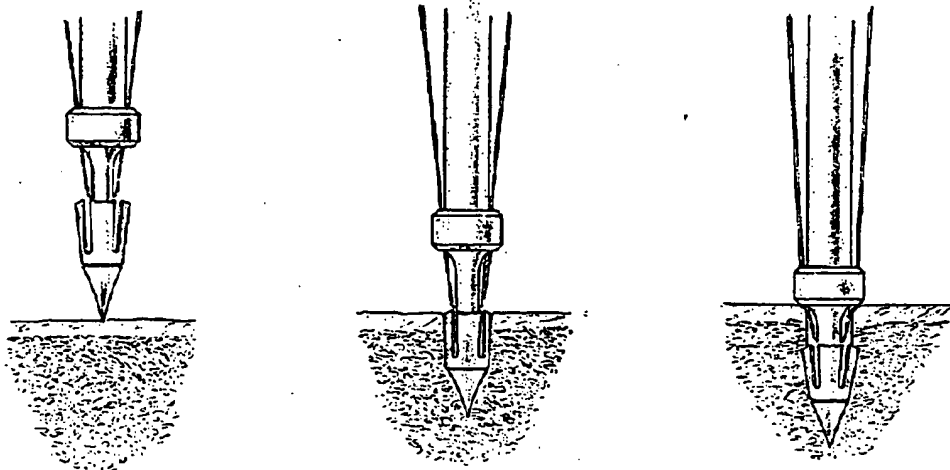
# Surgical Technique for Standard Harpoon

## Preparation

Prepare the bony bed. Take care not to remove all of the cortical bone.

## Step One

Place the anchor perpendicular to the location on the bone where the anchor will be implanted. Gently tap the end of the handle until driver collar is seated on the cortical bone.



## Step Two

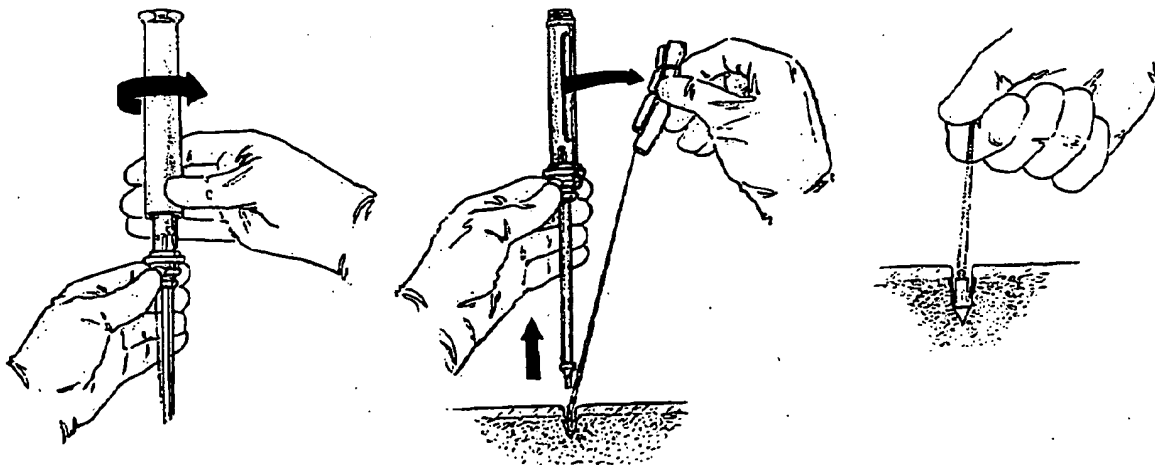
Disassemble the handle by holding the lower section of the handle while unscrewing the upper section.\*

## Step Three

Take the foam insert out of the driver handle and pull the driver straight out, leaving sutures exiting from the bone.\*

## Step Four

Apply gentle tension to the sutures to ensure the Harpoon is properly seated.

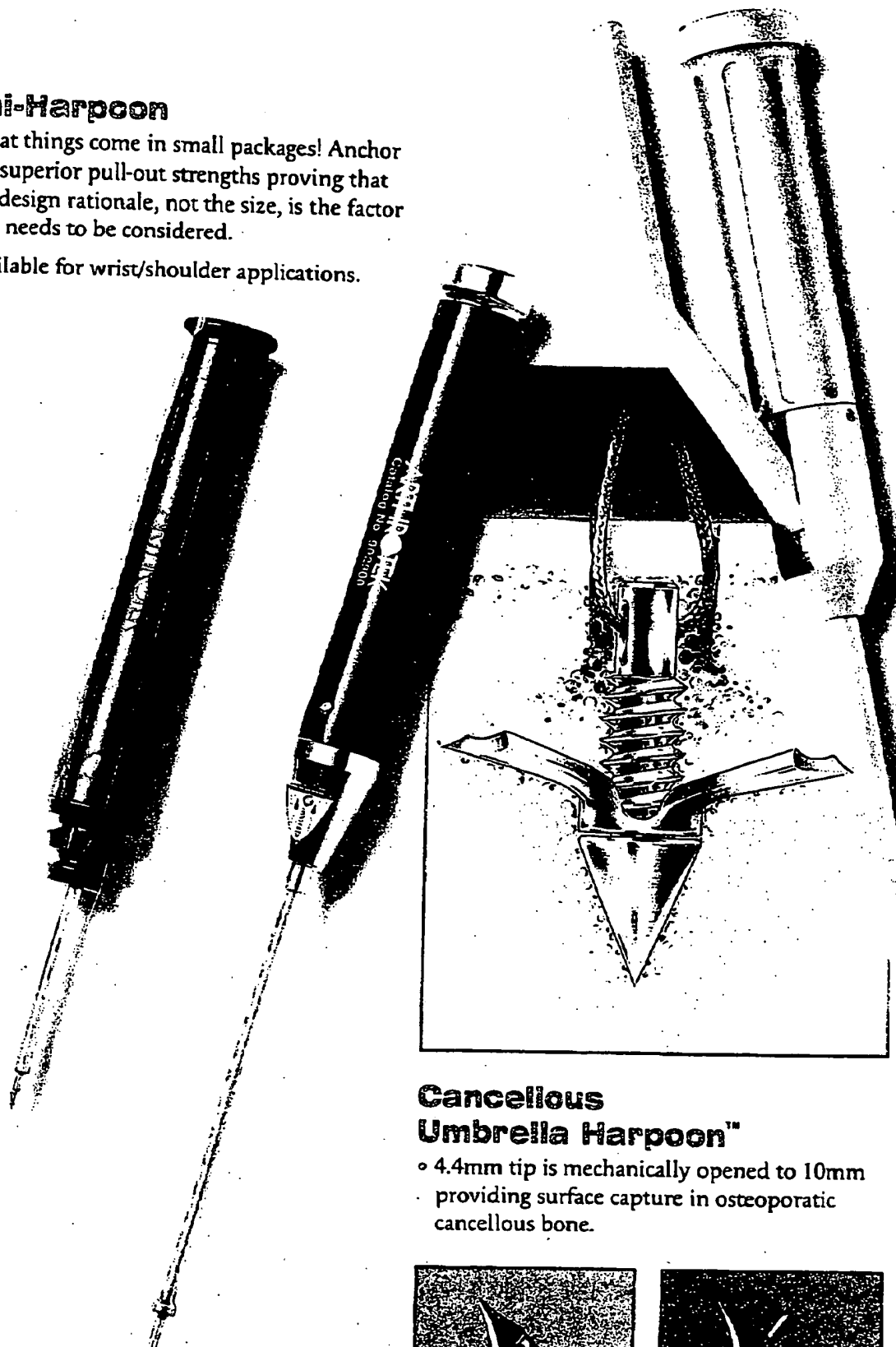


\*Do not twist the driver shaft once the anchor is inserted into bone since this can damage sutures.

Arthrotek, as the manufacturer of this device, does not practice medicine and does not recommend this or any other surgical technique for use on a specific patient. The surgeon who performs any procedure is responsible for determining and utilizing the appropriate techniques for such procedure for each individual patient. Arthrotek is not responsible for selection of the appropriate surgical technique to be utilized for an individual patient.

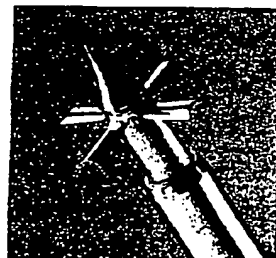
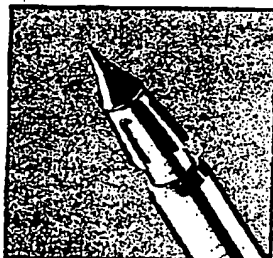
## Mini-Harpoon

- Great things come in small packages! Anchor has superior pull-out strengths proving that the design rationale, not the size, is the factor that needs to be considered.
- Available for wrist/shoulder applications.



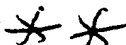
## Cancellous Umbrella Harpoon™

- 4.4mm tip is mechanically opened to 10mm providing surface capture in osteoporotic cancellous bone.



## Limited Reusable Handle

- Utilized by surgeons that desire to load their own sutures and needles.



## Ordering Information

### Collarless Harpoon

902920 #2 Suture

### Calibrated Needle

902905

### Mini-Harpoon – Short Shaft

902922 #1-0 Suture

902923 #2-0 Suture

### Mini-Harpoon – Long Shaft

902933 #1-0 Suture

902934 #1-0 Suture

### Collared Harpoon

902928 #1 Suture

902929 #2 Suture

902939 #2 Suture (x2)

902959 #5 Suture

### Limited Reusable Harpoon Handle

902900

### Limited Reusable Driver Shaft

902902

### Sutureless Harpoon Tip

902913 #2 Suture

### Umbrella Cancellous Harpoon

902998 Handle

902999 #2 Suture (pkg. 5)

### Mini-Harpoon Step Drill

902903 1.6mm

902904 1.8mm

Arthrotek and Harpoon are registered  
trademarks of Arthrotek, Inc.

Umbrella Harpoon is a trademark of  
Arthrotek, Inc.

U.S. Patent No. 5,537,432

1. Barber, Alan F; Strength of Sutures  
and Suture Anchors: Update 1997.

Presented at the San Diego Shoulder  
Arthroscopy Course, San Diego,  
California, June 1997.

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Form No. Y-BMT-553/031598/M

# Suture Punch Surgical Technique



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# Arthroscopic Rotator Cuff Repair Technique

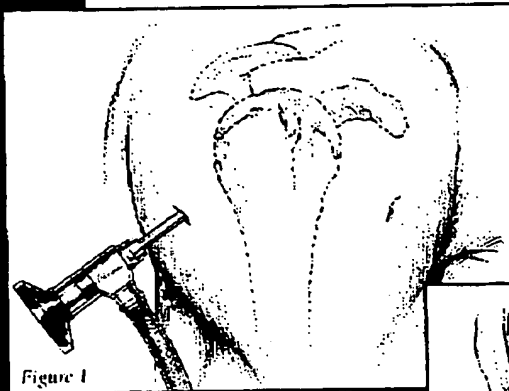


Figure 1

After completing a thorough glenohumeral arthroscopic examination, the arthroscope is inserted into the subacromial bursa via the posterior portal [Figure 1].



Figure 2

The rotator cuff tear is evaluated arthroscopically. Erosion on the inferior and anterior aspect of the acromion and acromial spurs is identified [Figure 2].



Figure 3

A lateral portal is created in line with the anterior acromion and approximately 3 cm lateral to the acromion. Using a spinal needle to locate the portal and line it up correctly with the anterior acromion is helpful [Figure 3].

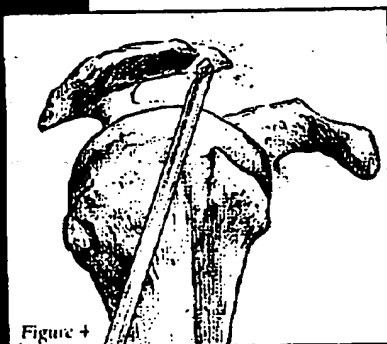


Figure 4

A shaver is inserted through the lateral portal and the thickened periosteum from the anterior 5mm of the acromion is debrided [Figure 4].

Using a burr, the anterior 5mm of the acromion is resected from lateral to medial. This step releases the coracoacromial ligament without excessive bleeding. Alternatively, an electrocautery may be used to release the ligament [Figure 5].

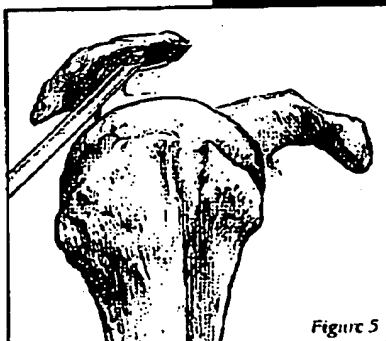


Figure 5



Figure 6

The rotator cuff tear is debrided back to good repairable tissue using a combination of arthroscopic punches and soft tissue shavers [Figure 6].

The arthroscope is then switched to the lateral portal and a soft tissue shaver is inserted via the posterior portal [Figure 7].

An excellent view of the rotator cuff tear and the morphology of the undersurface of the acromion is seen from the lateral portal. The periosteum on the inferior aspect of the acromion is debrided [Figure 8].

A burr is placed in the posterior portal and positioned so that the burr tip is at the deepest point of the concavity of the acromion and the shank rests on the posterior point of the acromion [Figure 9].

By sweeping the burr back and forth (medially and laterally) and advancing anteriorly, the anterior acromion is flattened to the shape of a Type I acromion.



Figure 7

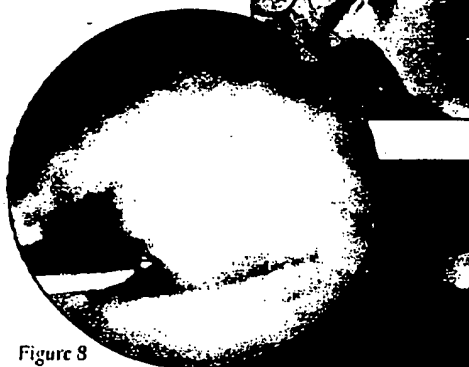


Figure 8

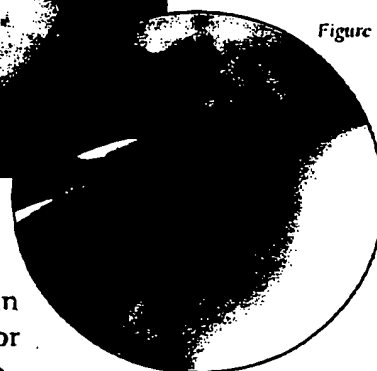


Figure 9

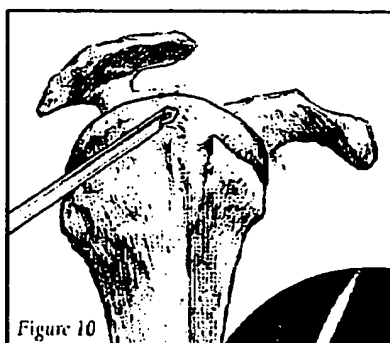


Figure 10

The burr is next used to cut a rough trough just medial to the greater tuberosity and adjacent to the articular margin to prepare a bed for healing of the rotator cuff [Figure 10]. Alternatively and at the surgeon's discretion, the periosteum can be resected leaving the cortex intact so as to provide stronger fixation for the Harpoon® anchors [Figure 11].

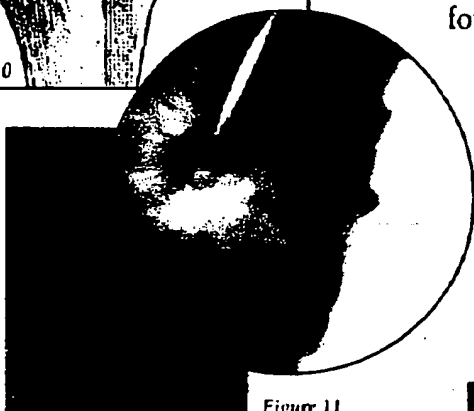


Figure 11

The arthroscope is switched back to the posterior portal and a Harpoon anchor is inserted through the lateral portal [Figure 12].

The Harpoon is inserted into the bone and the inserter removed [Figure 13].

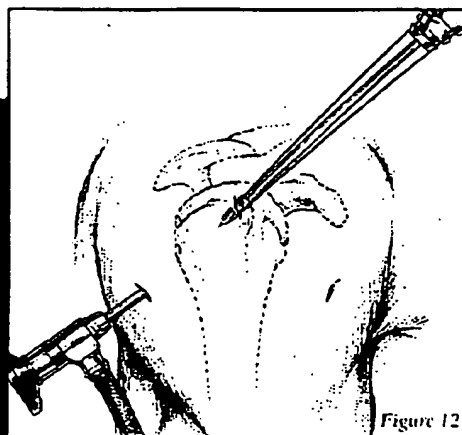


Figure 12



Figure 13

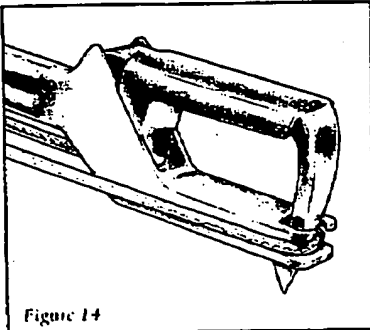


Figure 14

Cut the needles from the suture to use the Suture Punch. Next, put a clamp on one leg of the suture and put the other leg of the suture through the groove in the front of the Suture Punch. Note: The Suture Punch must be completely closed when loading the suture on the punch or the punch will not work properly. Looking at the suture, it will be in the groove in front of the needle on the Suture Punch [Figure 14].

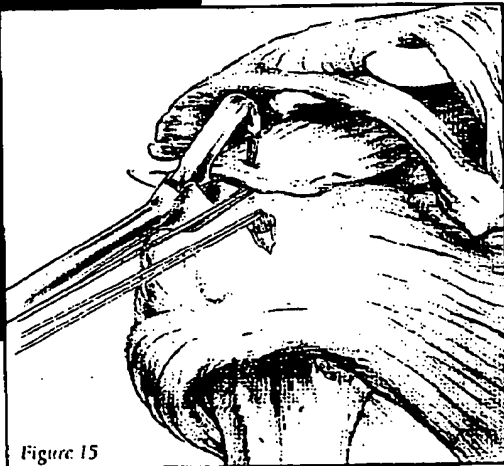


Figure 15

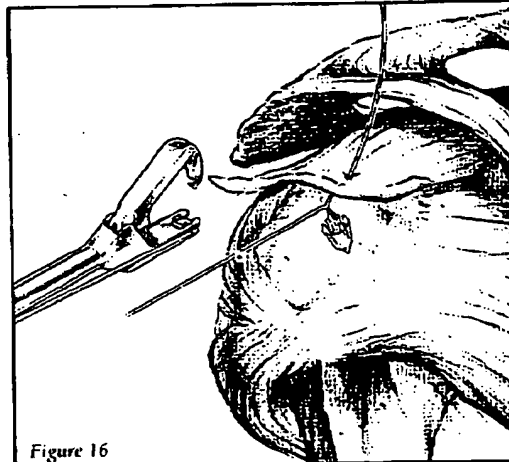


Figure 16

Open the Suture Punch, keeping tension on the suture, punch through the tissue and release tension from the suture. You will notice the positive tactile feeling or "snap." While opening the Suture Punch, it is best to gently push forward so as not to catch the needle on any tissue [Figure 15]. The second arm of the suture is placed in the cuff with the Suture Punch thus creating a mattress suture [Figure 16].

This will leave the soft tissue ready to be fixated to the bone and the legs of the suture exiting the cannula [Figure 17].

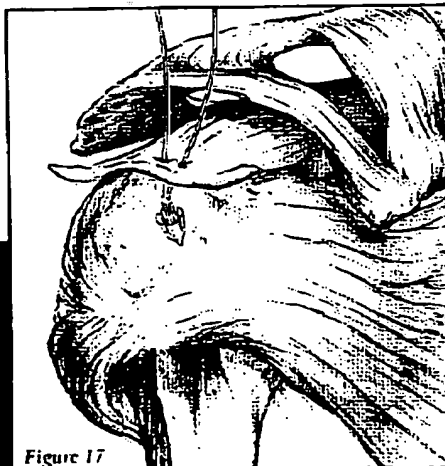
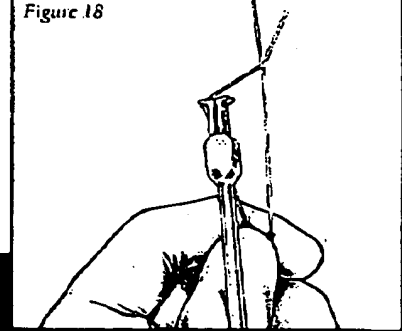


Figure 17

punch needed to penetrate through tissue if needle is not used as in arthroscopic method.

Throw a simple overhand knot. With the tension on the suture, hook one eyelet of the Nordt™ Knot Tightener to one leg of the suture and slide down to the knot [Figure 18]. Next engage the second limb of the suture.

Figure 18



Advance the knot down to the sutured tissue. The knot may be "teased" by gently spreading the arms of the Knot Tightener if the knot kinks or meets resistance [Figure 19].

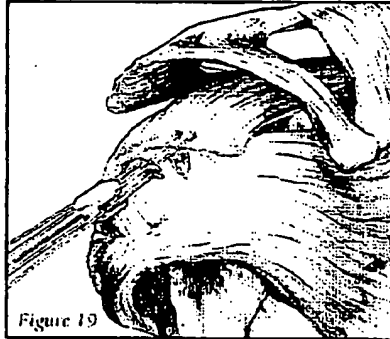
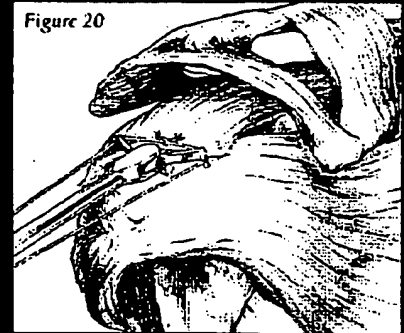


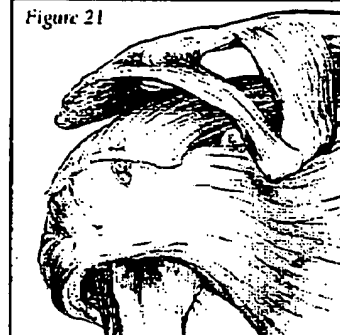
Figure 20



Open the arms of the Knot Tightener to cinch the knot [Figure 20]. Repeat the procedure using a second overhand knot in the same direction, working the double hitch down by spreading the arms and teasing the knot until flat.

Repeat the procedure with several alternating overhand knots [Figure 21].

Figure 21



\* Subsequent anchors and sutures are placed as required to close the cuff [Figures 22 & 23].

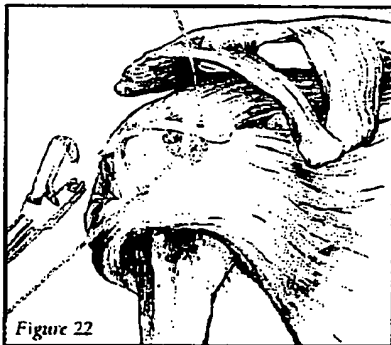
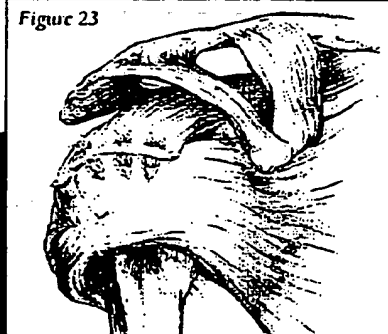


Figure 23



## Ordering Information

### Suture Punch

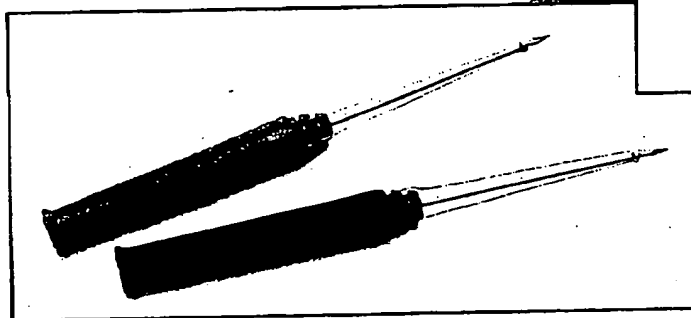
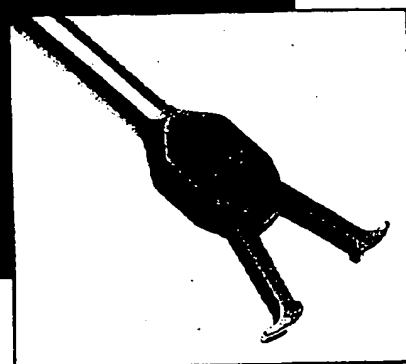
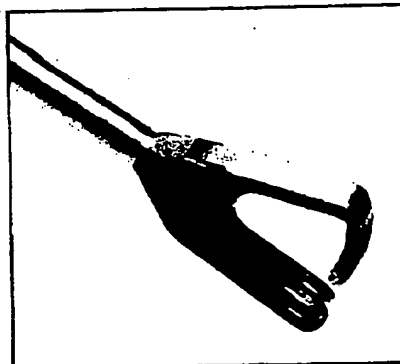
- 901070 Standard - Straight
- 902070 Mini - Straight
- 902071 Mini - Left
- 902072 Mini - Right
- 902073 Mini - 15° Up

### Nordt™ Knot Tightener

901477

### Collared Harpoon®

- 902928 #1 Suture
- 902929 #2 Suture
- 902939 Double #2 Suture
- 902959 #5 Suture



Suture Punch developed in conjunction with Richard B. Caspari, M.D.

Nordt Knot Tightener developed in conjunction with William E. Nordt, M.D.

U.S. Patent No. 5,522,820

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Nordt is a trademark of Biomet, Inc.

Harpoon is a registered trademark of Biomet, Inc.

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Mitek 2.0 mm  
Tacit™ Threaded Anchor



Surgical Technique:

Scapholunate  
Surgical  
Technique  
Using the Mitek  
2.0 mm Tacit™  
Threaded Anchor

*by Walter H. Short, M.D.*

**Mitek®**

# Scapholunate Surgical Technique

## *Using the Mitek 2.0 mm Tacit™ Threaded Anchor*

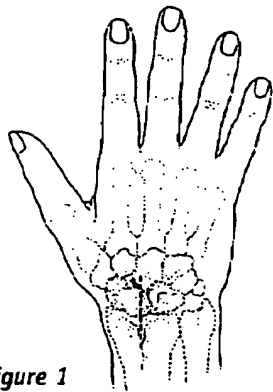


Figure 1

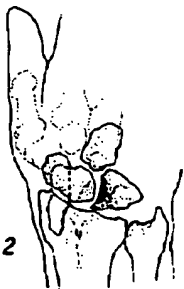


Figure 2

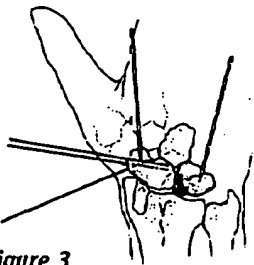


Figure 3

Complete tears of the scapholunate interosseous ligament (SLIL) can lead to instability of the carpus. This injury most commonly occurs by longitudinal force on the outstretched hand. Patients present in the office with pain, swelling and occasional clicking within the wrist. On physical examination, there is usually a swelling over the dorsum of the wrist. Palpation of the wrist reveals pain that is centered over the scapholunate interval, which is distal and slightly ulnar to Lister's tubercle. If these symptoms persist, then an evaluation is warranted. Plain x-rays and wrist motion studies may either be normal or show a dorsal intercalated segment instability pattern. Another finding on the x-ray may be an abnormal gap between the scaphoid and lunate. Triple compartment arthrograms in many cases may confirm the clinician's suspicion that there is a tear of the SLIL. Diagnostic arthroscopy of the radial carpal joint can confirm a tear of the SLIL. This tear typically is seen as a detachment of the ligament from its insertion into the scaphoid. Arthroscopic assessment should also confirm that the ligament can be repaired. Midcarpal arthroscopy can assess the degree of instability between the scaphoid and lunate. Surgical repair is indicated when clinical symptoms persist in spite of immobilization and activity modification, and workup of this problem reveals a repairable tear of the scapholunate ligament. Other causes of wrist pain should be ruled out.

One method of surgical repair of this lesion is to suture the SLIL back to the bone by means of drill holes placed through the scaphoid, as well as doing a dorsal capsulodesis to the scaphoid by using pull-out wires. These surgical procedures have been described by Blatt<sup>1</sup> and Lavernia et al.<sup>2</sup> This operation can be facilitated by the use of the Mitek 2.0 mm Tacit Threaded Anchors.

### *Surgical Procedure*

A 6-8 cm longitudinal incision is made over the dorsal aspect of the wrist. This incision is centered over the Lister's tubercle (*Figure 1*). The subcutaneous veins are coagulated. The extensor retinaculum is then identified and the third dorsal compartment is located. An incision is made through the extensor retinaculum and is then reflected radially and ulnarward. The extensor tendons are then retracted, exposing the dorsal capsule of the wrist. The wrist is then flexed and the scaphoid, lunate and scapholunate interval can be palpated. Two longitudinal incisions are made in the dorsal capsule approximately 1 cm apart, centered over the central portion of the scaphoid. These incisions are connected distally at the level of the distal pole of the scaphoid. This creates a proximally based capsular flap that will be used for the dorsal capsulodesis portion of the procedure (*Figure 2*). The dorsal wrist capsule ulnar to this flap is carefully dissected and separated from the SLIL. When this portion of the procedure is complete, the dorsal aspect of the scaphoid and lunate

should be well visualized and the torn SLIL should also be seen. In the majority of cases, the ligament remains attached to the lunate and is avulsed from the scaphoid. Two .062 in. K-wires are then inserted from dorsal to volar, one into the scaphoid and the other into the lunate. These then act as joysticks to manipulate the scaphoid and lunate. A C-arm is then brought into the surgical field and under fluoroscopic control, two .045 in. K-wires are inserted percutaneously through the anatomic snuffbox. The K-wires are then drilled through the scaphoid and directed so as to pass through the scapholunate joint and into the lunate. These K-wires are left in the subchondral bone underneath the articular surface of the scaphoid at the scapholunate joint. A third .045 in. K-wire is inserted through the snuffbox, but directed through the scaphoid toward the body of the capitate. At this point in the procedure, this K-wire is left in the scaphoid and should not traverse the scaphocapitate joint (*Figure 3*).

At this juncture, the wrist is flexed and the scapholunate joint distracted by use of the joysticks. The insertion of the SLIL where it was avulsed from the scaphoid is debrided to subchondral bone. Three drill holes are made into the prepared site on the scaphoid with the Mitek 1.7 mm anchor drill. These drill holes are placed so that one is in the dorsal aspect of the scaphoid, one is in the midportion of the ligament and the third is in the volar portion of the ligament (*Figure 4*). The anchor is then prepared and a 3-0 PDS® suture is placed on the anchor. The 2.0 mm Tacir™ Threaded Anchor is then inserted into the prepared drill hole in the scaphoid (*Figure 5*). The sutures are placed through the ligament by the use of free needles. The sutures are positioned so that the knots are on the proximal surface of the ligament. After the sutures are placed, the wrist is extended to neutral (*Figure 6*). Under fluoroscopic control, the scapholunate interval is reduced and the two K-wires are passed across the scapholunate joint into the lunate. Fluoroscopy should confirm that there is no gap between the scaphoid and lunate, no malrotation between the two carpal bones and the anchors are positioned appropriately. The wrist is then flexed and sutures in the SLIL are then tied so as to appose the ligament to the subchondral prepared bone of the scaphoid (*Figure 7*). The C-arm is then used and the position of the scaphoid is reduced by means of the joysticks, so that a normal relationship between the scaphoid, lunate, radius and capitate is maintained. When this is confirmed on the C-arm, the third K-wire, which was previously inserted, is advanced across the scaphocapitate joint into the capitate. Further fluoroscopic views should confirm that normal anatomic relationships have been restored and that the K-wires are appropriately placed. The .062 in. K-wires that were used for joysticks are then removed.

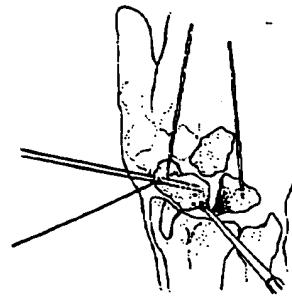


Figure 4

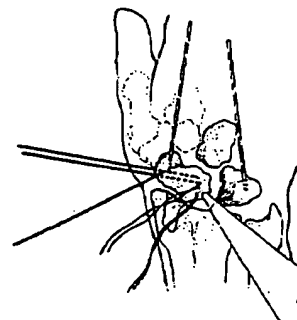


Figure 5

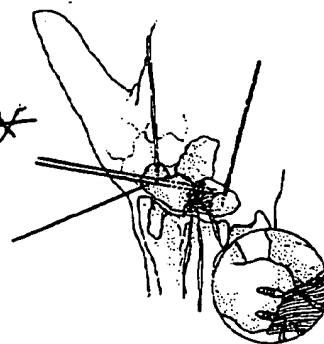


Figure 6

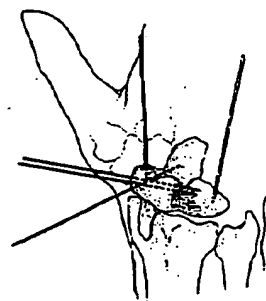


Figure 7

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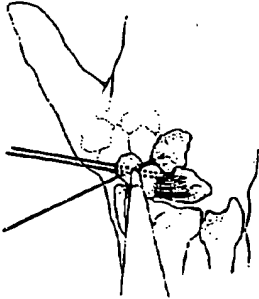


Figure 8

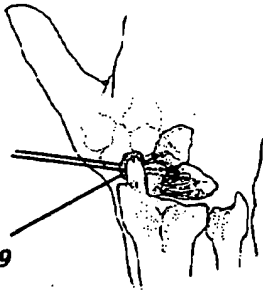


Figure 9

Another Mitek 2.0 mm Tacit™ Threaded Anchor is prepared using 3-0 PDS® suture. This anchor is placed in the distal dorsal aspect of the scaphoid just proximal to the distal pole of the scaphoid (Figure 8). The suture is then passed through the previously prepared dorsal capsular flap. The suture is placed so that when the capsular flap is brought down to the insertion site of the anchor, it is taut. The suture is then tied thus creating a capsulodesis, as described by Blatt (Figure 9). The remaining dorsal capsule is then closed with nonabsorbable sutures. The extensor retinaculum is then repaired back to itself using absorbable sutures. The tendon of the extensor pollicis longus is left out of the extensor retinaculum to facilitate closure of this structure. The subcutaneous tissue is then closed and the skin is closed following this. The K-wires that were used to hold the position of the carpal bones are then cut and left protruding through the skin. At the end of this procedure, a sugartong splint is applied.

Approximately one week after the procedure, the patient is brought back to the office, the sutures are removed and the patient is placed in a thumb spica muenster cast. This cast is left on for three weeks. The cast is then changed to a short arm thumb spica cast. The patient is kept casted for a period of eight weeks from the time of surgery. At the end of this immobilization period, the patient is sent to physical therapy for a progressive rehabilitation program that initially includes active exercises and then gradually progresses to passive and resistive exercises and strengthening.

### References:

1. Blatt G. Capsulodesis in reconstructive hand surgery: dorsal capsulodesis for the unstable scaphoid and volar capsulodesis following excision of the distal ulna. *Hand Clinics*. 3:81-102, 1987.
2. Lavernia CJ, Cohen MS, Taleisnik J. Treatment of scapholunate dissociation by ligament repair and capsulodesis. *J Hand Surg*. 17 (2) : 354-9, 1992.

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